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THE UK'S BIGGEST SELLING ASTRONOMY MAGAZINE

Sky at Night

#168 MAY 2019

THE SILENT SUN

IS OUR LOCAL STAR ON THE VERGE OF A NEW SOLAR CYCLE?

PLUS: YOUR GUIDE TO SOLAR OBSERVING

ON TEST

STARWAVE ASCENT 102ED REFRACTOR

ON LOCATION: KIELDER FOREST'S DARK SKIES

MISSING EXOPLANETS: THE SEARCH IS ON

GOOD LIBRATIONS: SEE HIDDEN LUNAR FEATURES

Welcome

Your solar observations reveal clues about our star's condition

Dark evenings rapidly become a distant memory at this time of year, but for us astronomers there is always our local star to observe. Indeed, the Sun can be one of the most rewarding targets to view as its visible surface can change in a matter of hours, bringing sunspots, prominences and other features into view. This month, director of the British Astronomical Association's Solar Section, Lyn Smith, is our guide to conducting solar astronomy safely, with an article on page 66.

Regular observers of the Sun will know that it has been rather quiet of late: while there have been sunspots, they've been fewer in number than compared to, say, four or five years ago. Solar activity occurs in a pattern, and the current level could be a signal that our star is reaching an important turning point in its 11-year cycle. Solar researcher, Professor Lucie Green of the Mullard Space Science Lab, takes up the story on page 30.

From the Sun to the Moon, and our pull-out Sky Guide this month has plenty of great lunar sights to take in, including a relatively rare chance to get a good look at the large crater Humboldt. Because this 200km-diameter impact crater is right on the edge of the Moon's eastern limb, it's not always easy to see. But this month, the slight wobble of the Moon's orbit brings it nicely into view at around the same time that the terminator, the line between the sunlit and dark parts of the Moon, is close by. You'll find more details of this, other lunar targets and many more of the month's best observing sights from page 43.

Enjoy the issue,

Chris Bramley, Editor

PS Our next issue goes on sale 23 May.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

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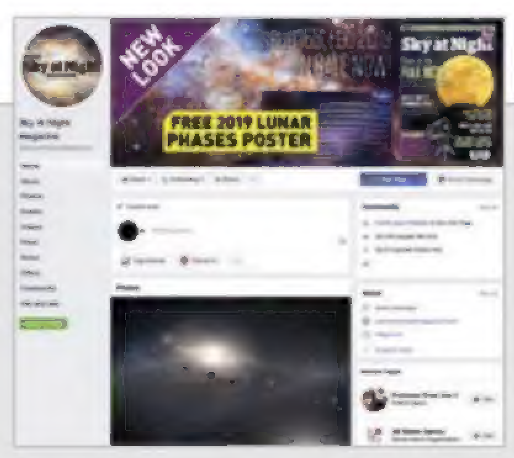
Visit our website for reviews, competitions, astrophotos, observing guides and our forum



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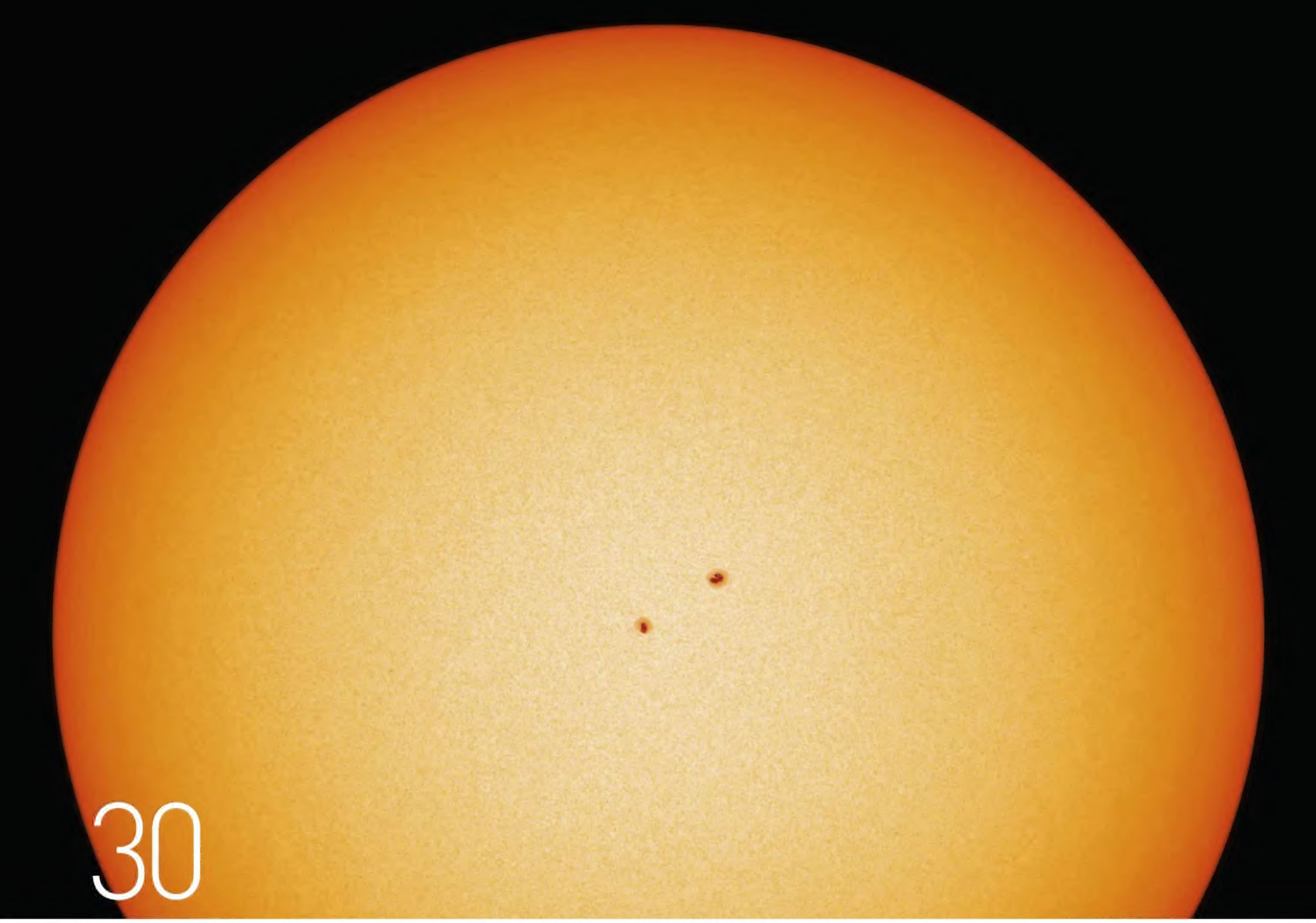

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Ⓒ = on the cover

COVER MAIN IMAGE: SOLAR DYNAMICS OBSERVATORY/NASA, THIS PAGE: SOLAR DYNAMICS OBSERVATORY/NASA, ZUMA PRESS/INC/ALAMY STOCK PHOTO, WWW.SECRETSTUDIO.NET, PETE LAWRENCE, DAN MONK, BBC

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners

This month's contributors

Lucie Green

Solar scientist

The Mullard Space Science Lab professor looks at what's behind the drop in sunspots. See page 30

Niamh Shaw

Analogue astronaut

As we approach the Moon landing's 50th anniversary, Niamh recounts NASA's test run. See page 68

Lyn Smith

BAA's Solar Section director

Lyn reveals the secrets you can discover about our nearest star by observing solar activity. See page 66

Stephen Tonkin

Binocular astronomer

Join Stephen's wide-field tour, from the Sombrero Galaxy to Markarian's Chain. Turn to page 54

Extra content ONLINE

- Visit **www.skyatnightmagazine.com/bonuscontent**
- Select May's Bonus Content
- Enter the code **MUUZQDP**

May highlights

Watch a classic episode

In this episode of *The Sky at Night* from 1 August 1973, Patrick takes a look at the Russian launches of the Mars 4 and 5 missions to the Red Planet. He then sets to sea on the cruise ship Monte Umbe with Commander Henry Hatfield for a spot of navigational astronomy.

Interview: new results from New Horizons

This month we speak to NASA's Carey Lisse, who reveals the latest updates from New Horizons' close flyby at the Kuiper Belt.

Sample the latest astro audio books

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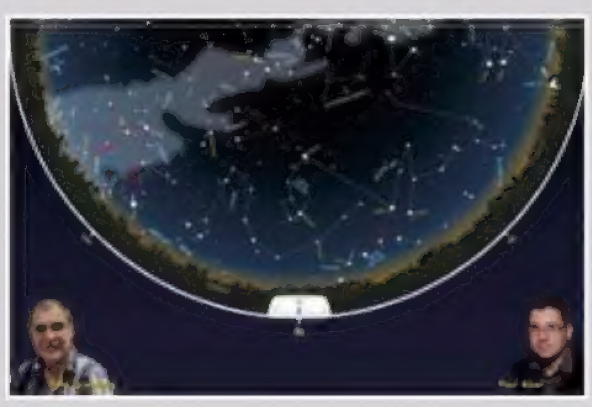


The virtual planetarium

May's night-sky highlights with Paul Abel and Pete Lawrence

EYE ON THE SKY

Black hole blowing bubbles

Supermassive black holes produce a lot of energy. Some generate huge bubble-like structures that create shockwaves felt on Earth

CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE, 28 FEBRUARY 2019

Galaxy NGC 3079 contains two 'superbubbles' stretching 4,900 and 3,600 lightyears across, respectively. These giant cosmic structures may be formed from matter falling into a supermassive black hole at the centre of a galaxy, releasing vast amounts of energy that produce cavities of hot gas.

At the bright centre of the galaxy is a pink blob, which is X-ray light emitted by the supermassive black hole, as seen by the Chandra X-ray Observatory. The pink structures emanating above and below this are the superbubbles.

Astronomers are still learning more about the processes that occur at these bubbles. As their outer edges collide with surrounding gas, it may accelerate particles to energies hundreds of times greater than those in the Large Hadron Collider on Earth. This could even be a source of the most powerful cosmic rays that bombard our planet. The bubbles themselves are not wholly immune to the chaos of space, and may be shaped and sculpted by powerful winds from hot young stars.

X-RAY: NASA/CXC/UNIVERSITY OF MICHIGAN/J-T LI ET AL/OPTICAL: NASA/STSCI

△ Two become one

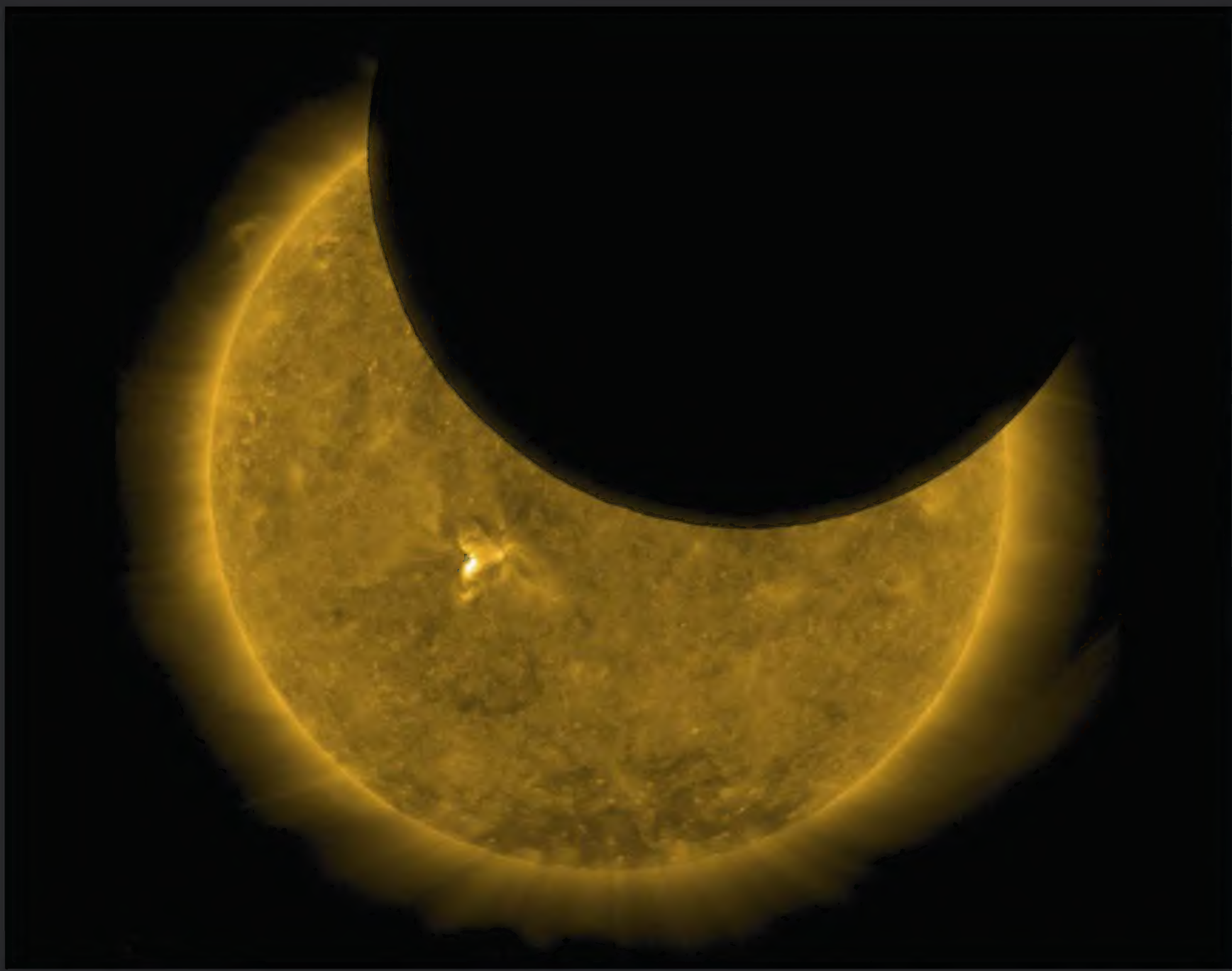
HUBBLE SPACE TELESCOPE, 4 MARCH 2019

Not all galaxies are beautiful spirals. This object, NGC 6052, is the product of a collision between two separate galaxies that were pulled together by gravity over time. Despite the merger, individual stars within the galaxies are unlikely to collide because the distances between them are so vast.

Studying the lives of stars ▷

VERY LARGE TELESCOPE, 18 MARCH 2019

The Tau Canis Majoris Cluster is found in the constellation of Canis Major and is an example of an open cluster. Each star was formed from the same molecular cloud but has evolved differently according to its mass. The fact that they are the same age provides an opportunity for astronomers to learn more about how stars are born, grow and eventually die.



◁ Shadow of the Moon

NASA SOLAR DYNAMICS OBSERVATORY, 6 MARCH 2019

While on Earth we can wait years for the next solar eclipse to occur, they are a regular sight for NASA's Earth-orbiting solar telescope, as it often observes the Moon passing in front of the Sun from its position in geosynchronous orbit. Note the crisp edge of the lunar silhouette; a result of our satellite's position beyond Earth's atmosphere.

Bright eyes ▷

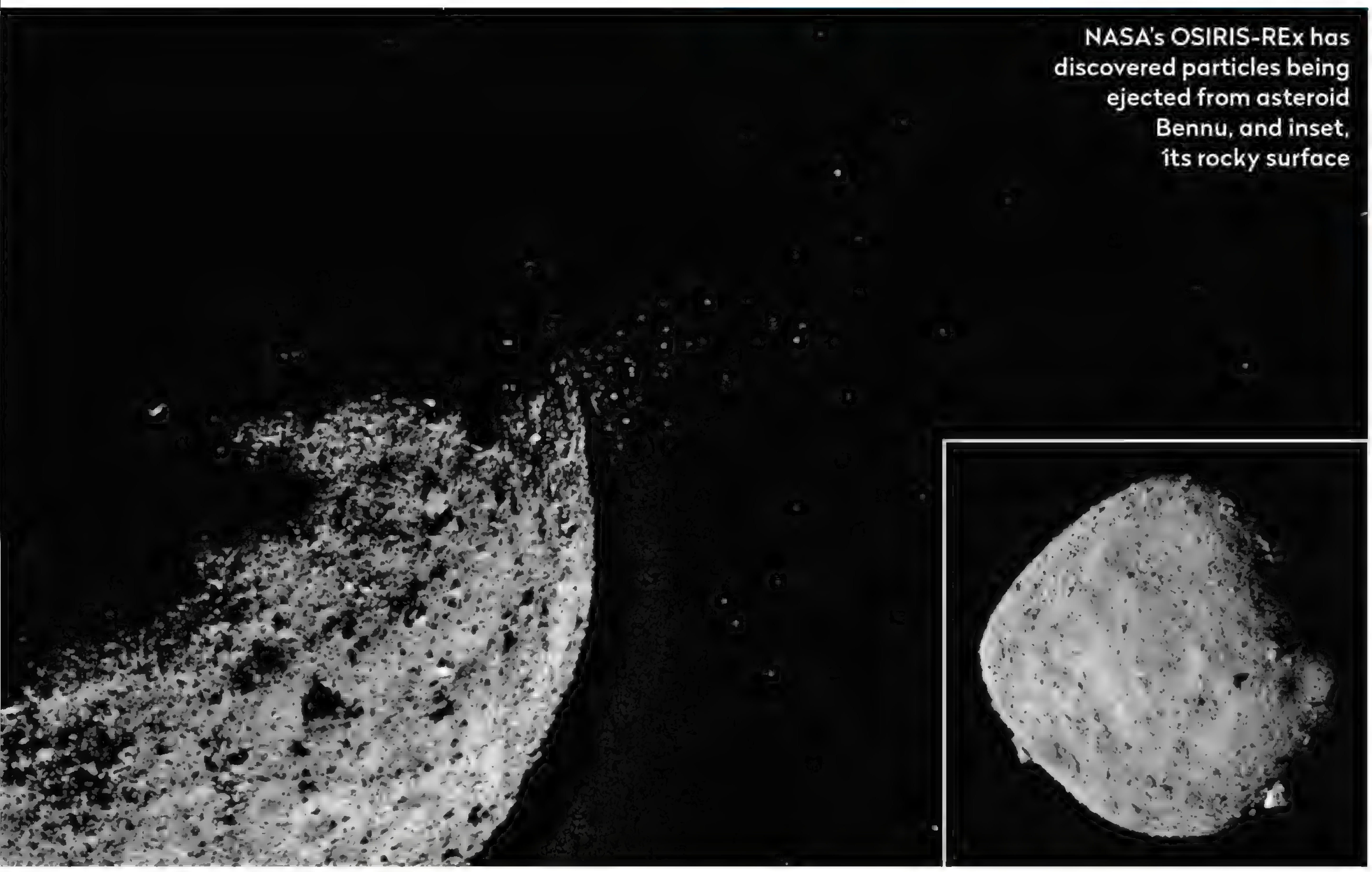
VERY LARGE TELESCOPE, 14 MARCH 2019

A pair of glowing eyes seem to peer out from behind a dark cloud of dust in this image of nebula NGC 1788. The two bright young stars illuminate gas in the background, and are powerful enough even to penetrate the dark, opaque dust in the foreground. This nebula's appearance has led it to be dubbed the Cosmic Bat.

More **ONLINE**
A gallery of these and more stunning space images

The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN



NASA's OSIRIS-REx has discovered particles being ejected from asteroid Bennu, and inset, its rocky surface

Scientists in a spin over BENNU AND THE JETS

Fast-spinning asteroid sends plumes of particles into space

Asteroid Bennu is proving to be an enigmatic body for planetary scientists exploring with NASA's OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer) spacecraft. They have discovered that it is ejecting plumes of particles from the surface into space.

The first close-up pictures revealed the asteroid's surface is littered with rocks and boulders, leaving mission planners struggling to find a spot to touch down next year and take a sample to return to Earth in 2023. But the ejection of jets of particles, observed since early January, was completely unexpected.

"The discovery of plumes is one of the biggest surprises of my career," says principal investigator Dante Lauretta, of the University of Arizona.

Some particles were observed to orbit Bennu as satellites before falling back to the surface. None of the plumes are seen as a threat to the probe as it orbits at a distance of around 1.6km.

The ejected plumes are unlike those from comets as they are warmed by the Sun. A clue to their cause may come from the balance that exists between Bennu's weak gravitational pull and its spin, which gives rocks enough energy to escape into space. "When you spin this guy up, you create a competition between the gravity that's holding you down and the centrifugal acceleration, which is trying to throw you off," says Daniel Scheeres, of the mission's radio science team at the University of Colorado Boulder.

Bennu's orbit brings it close to Earth as a potentially hazardous object. Dust particles ejected in the past may even produce a minor meteor shower. www.asteroidmission.org

NASA/GODDARD/UNIVERSITY OF ARIZONA/LOCKHEED MARTIN, X 2

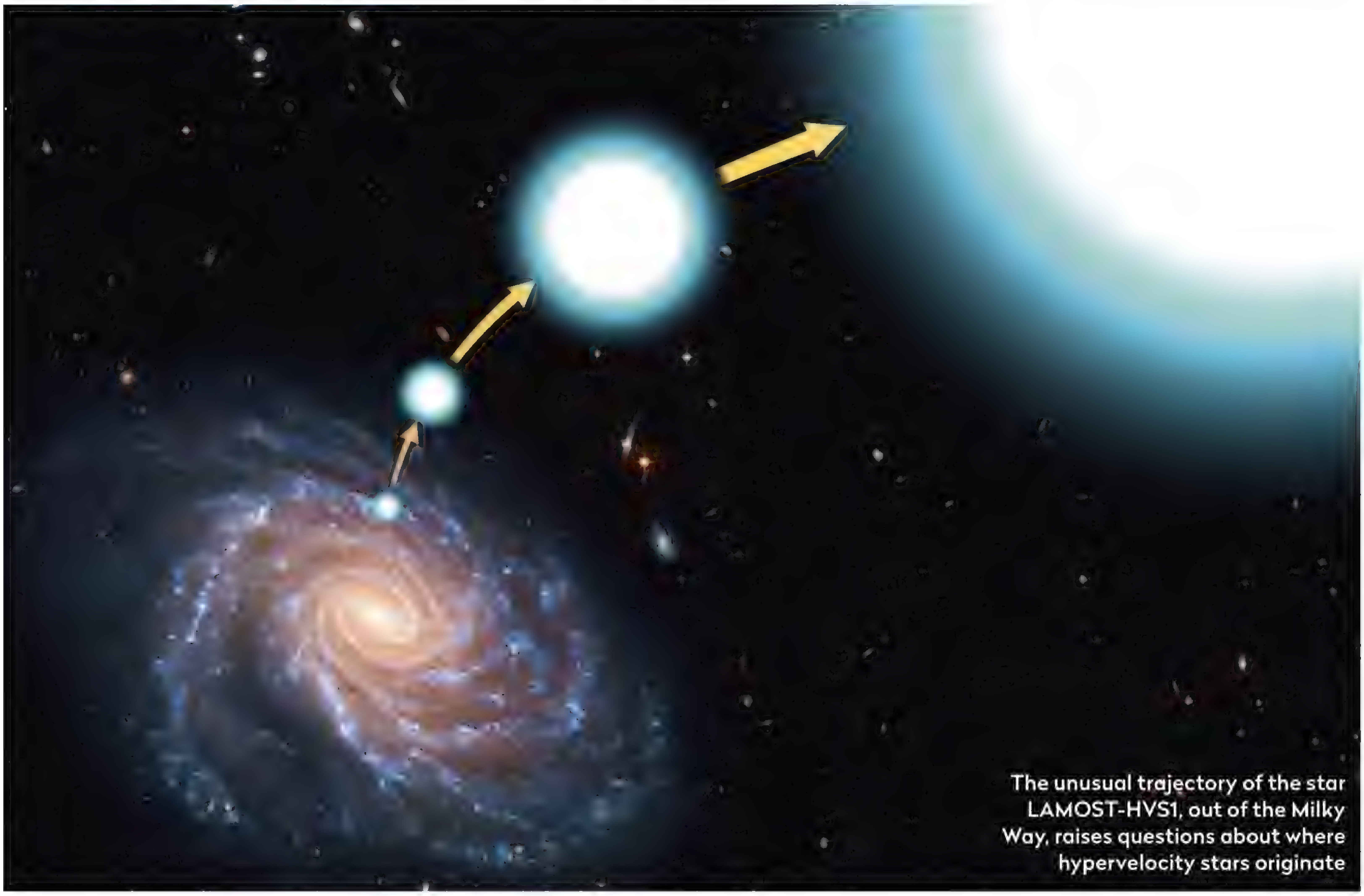
Comment
by Chris Lintott

The ejection of particles isn't the only surprise OSIRIS-REx has uncovered at Bennu. While the particles thrown into space pose no threat to the mission, the rugged surface is a serious problem.

The scientific pay-off from OSIRIS-REx's voyage is supposed to come from its return of asteroid samples to Earth, where a range of analysis techniques can be used.

First, you have to get your sample back home, though the lack of a large smooth surface makes that harder. It might be possible to access a couple of patches of dirt, 10cm across. To understand this inexplicable world – having travelled over two billion km – we might need the spacecraft to hit a bullseye.

Chris Lintott co-presents *The Sky at Night*



The unusual trajectory of the star LAMOST-HVS1, out of the Milky Way, raises questions about where hypervelocity stars originate

What gave runaway star the boot?

A hypervelocity star escaping the Milky Way may have been sent flying by a star cluster

A runaway star that has been ejected from the Milky Way at high speed is intriguing astronomers investigating where it came from.

Such fast-moving stars are usually thought to have been sent flying by the actions of the supermassive black hole at the centre of our Galaxy. However, detailed measurements of the motion and trajectory of the escaping star, labelled LAMOST-HVS1, show that it did not originate from the heart of our Galaxy.

Instead it appears to have originated from a location within the main disk of the Milky Way. Astronomers at the University of Michigan suggest that the massive star was ejected by a cluster of young stars, 33 million years ago.

The first so-called hypervelocity star – one that travels at more than 500km per second – was discovered in 2005, and still fewer than 30 are known. Normal stars generally move around 200km per second.

It was thought that stars reach such terrific speeds when a binary system of stars orbiting each other passes too close to a black hole. One gets captured by the black hole and the other is flung away at very great speed.

Astronomers have assumed that because a supermassive black hole appears to lie at the centre of the Milky Way, that must be responsible for most of the hypervelocity stars observed.

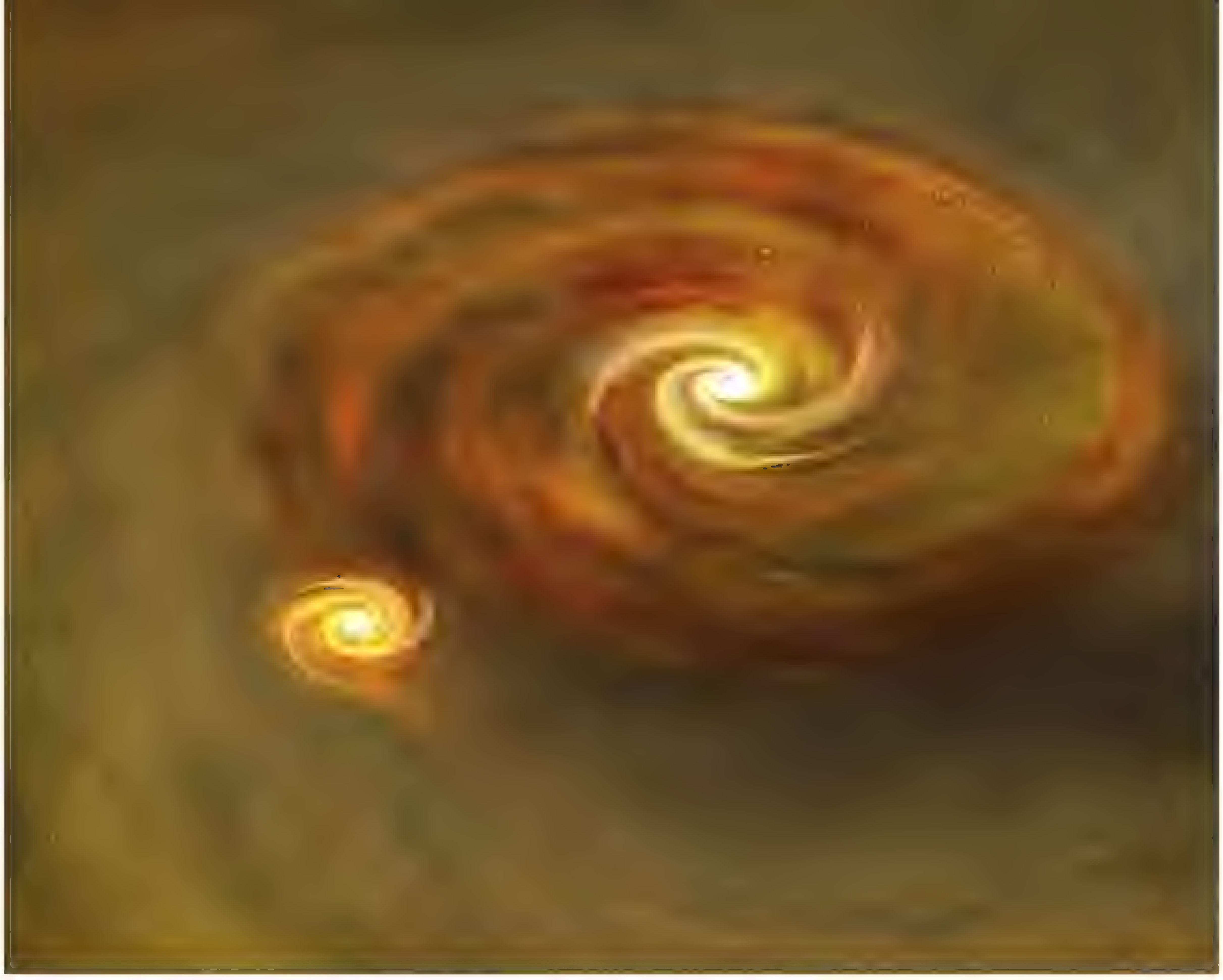
"This discovery changes our view on the origin of fast-moving stars," says professor Monica Valluri. "It indicates that the extreme environments needed to eject fast-moving stars can arise in places other than around supermassive black holes."

Valluri and University of Michigan postdoctoral researcher Kohei Hattori used one of the Magellan telescopes in Chile to determine the distance and velocity of the star. Hattori then joined a group of international scientists who analysed data from the European Space Agency's Gaia mission that precisely mapped stars within the Milky Way in 3D.

By combining the Magellan observations with Gaia data, the astronomers were able to trace back the star's path. They found, much to their surprise, that it originated from within the Norma spiral arm of the Milky Way.

The authors theorise that the star may have been kicked out by a close encounter with several massive stars or a moderate-sized black hole in a stellar cluster.
http://sci.esa.int/gaia/

NASA/ESA AND G. BACON (STSCI), B. SAXTON/NRAO/AUI/NSF, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE/NATIONAL OPTICAL ASTRONOMY OBSERVATORY, MARK GARLICK



▲ An artist's impression of PDS 27, the pair of high-mass binary stars found in Canis Major

Closest high-mass binary stars discovered

Young companions allow us to test theories of stellar formation

Astronomers have found the closest known pair of high-mass stars, 8,000 lightyears away in Canis Major. Catalogued as PDS 27, the stars in the binary system lie just 4.5 billion km apart, which is similar to the distance in our Solar System between Neptune and the Sun.

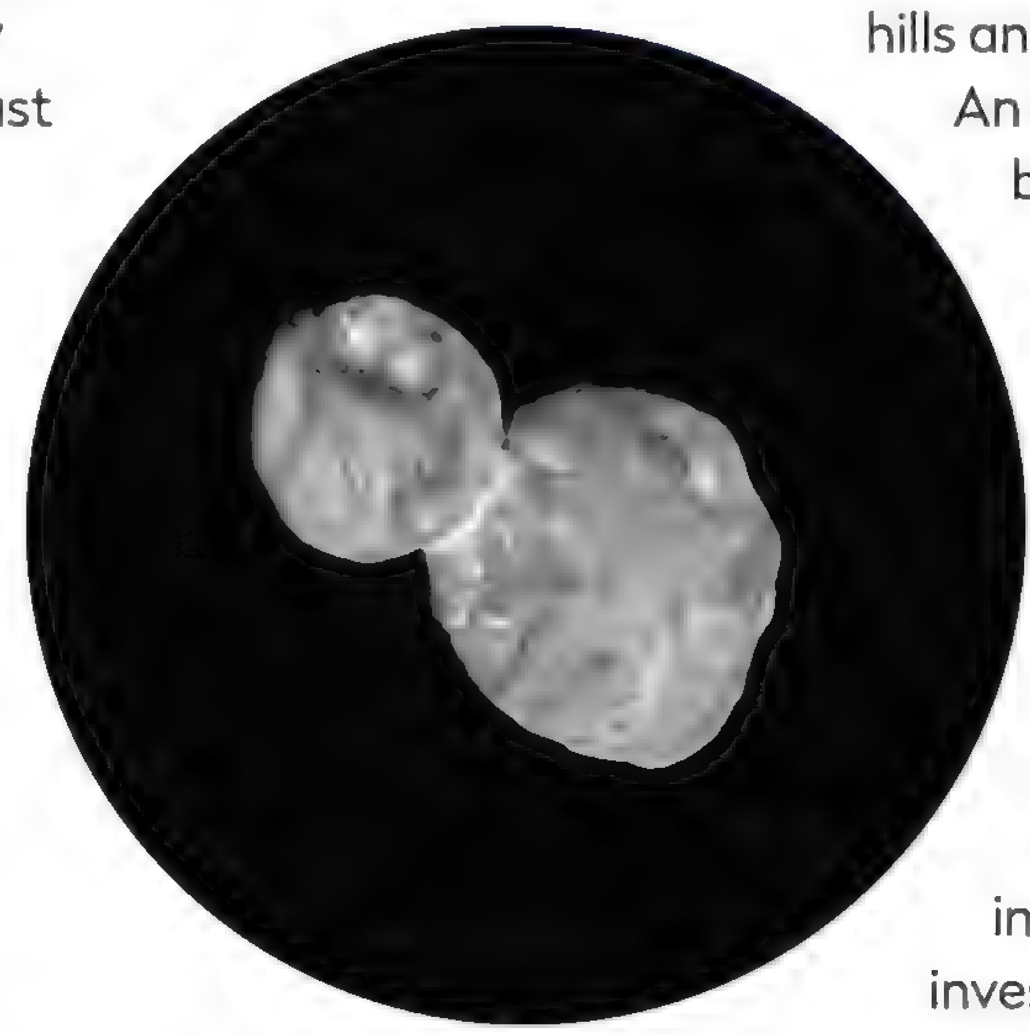
The pair of stars, which will have a comparatively short lifespan of only a few million years before they explode as a supernova, are at least 10 times more massive than the Sun when combined.

Dr Evgenia Koumpia, of the University of Leeds, led an international team in studying the star system, which shines at a dim mag. +13 because of its distance. They say the findings made using Europe's Very Large Telescope (VLT) in Chile, provides them with a valuable 'laboratory' to test theories on how high-mass binary stars form. www.eso.org

Ultima Thule gives up more secrets

NASA scientists are learning more about Ultima Thule, the 35-km long object in the Kuiper Belt that its New Horizons spacecraft flew past on 1 January.

The twin-lobed body appears to resemble a gingerbread man more than a snowman because it is flat rather than round. It is thought to have formed when two pristine relics of the early Solar System, called planetesimals, gently merged. This seems to be a demonstration of how the collisions by planetesimals built up the planets.



▲ Gingerbread man? Ultima Thule has whetted the New Horizons team's appetite for finding another Kuiper Belt object

Geologists are also trying to understand the surface features, including bright spots, hills and troughs, craters and pits. An 8km-wide depression has been nicknamed Maryland crater. But the team are unsure whether this and other depressions are craters caused by impacts or have other causes such as ice escaping as gas.

New Horizons, now 6.6 billion km from Earth, is still in good health and principal investigator Alan Stern hopes NASA will approve an extended mission to find a third Kuiper Belt target. http://pluto.jhuapl.edu

NEWS IN BRIEF

Binaries boost for life

The chances of life occurring on planets can be boosted in binary star systems, suggests a new study. In young star clusters, a passing third star can push a pair of others closer together, increasing the size of the warm habitable zone around them where water can exist as a liquid, says the University of Sheffield's Bethany Wootton and Dr Richard Parker.

Cannonball pulsar

A pulsar discovered by citizen scientists in the Einstein@home project is rocketing through space at 4 million km/h. Dubbed PSR J0002+6216, and lying in Cassiopeia, 6,500 lightyears away, it has a radio-emitting tail, 13 lightyears long, which points towards the site of a recent supernova explosion.

Pathfinder's sea visit

NASA's first rover mission to Mars, Pathfinder, landed on the edge of an ancient sea, new studies show. Its rover, Sojourner, arrived in 1997 and imaged features that suggest flooding 3.4 billion years ago. The landing site marked a spillway between a northern ocean and an inland sea, writes Planetary Science Institute head scientist Alexis Rodriguez.

NEWS IN BRIEF

Exoplanet storm detected

The first direct observation of an exoplanet has been made using the Very Large Telescope (VLT) in Chile. Astronomers combined its four giant instruments, a technique called interferometry, to observe a super-Jupiter, HR 8799e, orbiting a young star 129 lightyears away in Pegasus. Sylvestre Lacour, of the Observatoire de Paris, suggests a storm is raging in the exoplanet's atmosphere.

Weighing the Milky Way

Astronomers have 'weighed' our Milky Way and conclude that it is equivalent to around 1.5 trillion Suns. The team used the Hubble Space Telescope and data from ESA's Gaia satellite. A small proportion of the mass is from about 200 billion stars and the Galaxy's supermassive black hole; the rest could be dark matter.

Early astrolabe found

An astrolabe excavated from a Portuguese shipwreck has been certified as the earliest known by Guinness World Records. The thin, 175-mm diameter device, a forerunner of the modern planisphere, was used for navigation on Vasco da Gama's second voyage to India in 1502–03.

ESO/L. CALÇADA, NASA, QUEEN'S UNIVERSITY BELFAST

BULLETIN

NASA told to accelerate return to the Moon

Trump wants astronauts to prepare for base at lunar south pole

The space race is back: an artist's impression of America's return to the Moon

The Trump administration has told NASA to speed up the return of humans to the Moon with a crewed mission to its south pole within five years. Vice President Mike Pence issued the challenge at a meeting of the National Space Council in Alabama, saying the US was in a race with China.

Pence said: "That next giant leap is to return American astronauts to the Moon within the next five years by any means necessary, and to establish a permanent presence on the Moon and prepare to put American astronauts on Mars."

Jim Bridenstine, Administrator of NASA, responded: "I know NASA is ready for the challenge of moving forward to the Moon, this time to stay."

To meet the timeline, NASA will have to accelerate the launch of their Space Launch System rocket, but it is currently unclear how this will be done within the current budget of $21.5 billion.
www.nasa.gov

Is the Sun as strong as a fridge magnet?

The Sun's magnetic field is 10 times more powerful than previously believed

A serendipitous measurement has led to the most accurate measurement of the Sun's magnetic field, it's been recently announced. The finding has revealed the field is 10 times stronger than previously thought, but still no stronger than a fridge magnet.

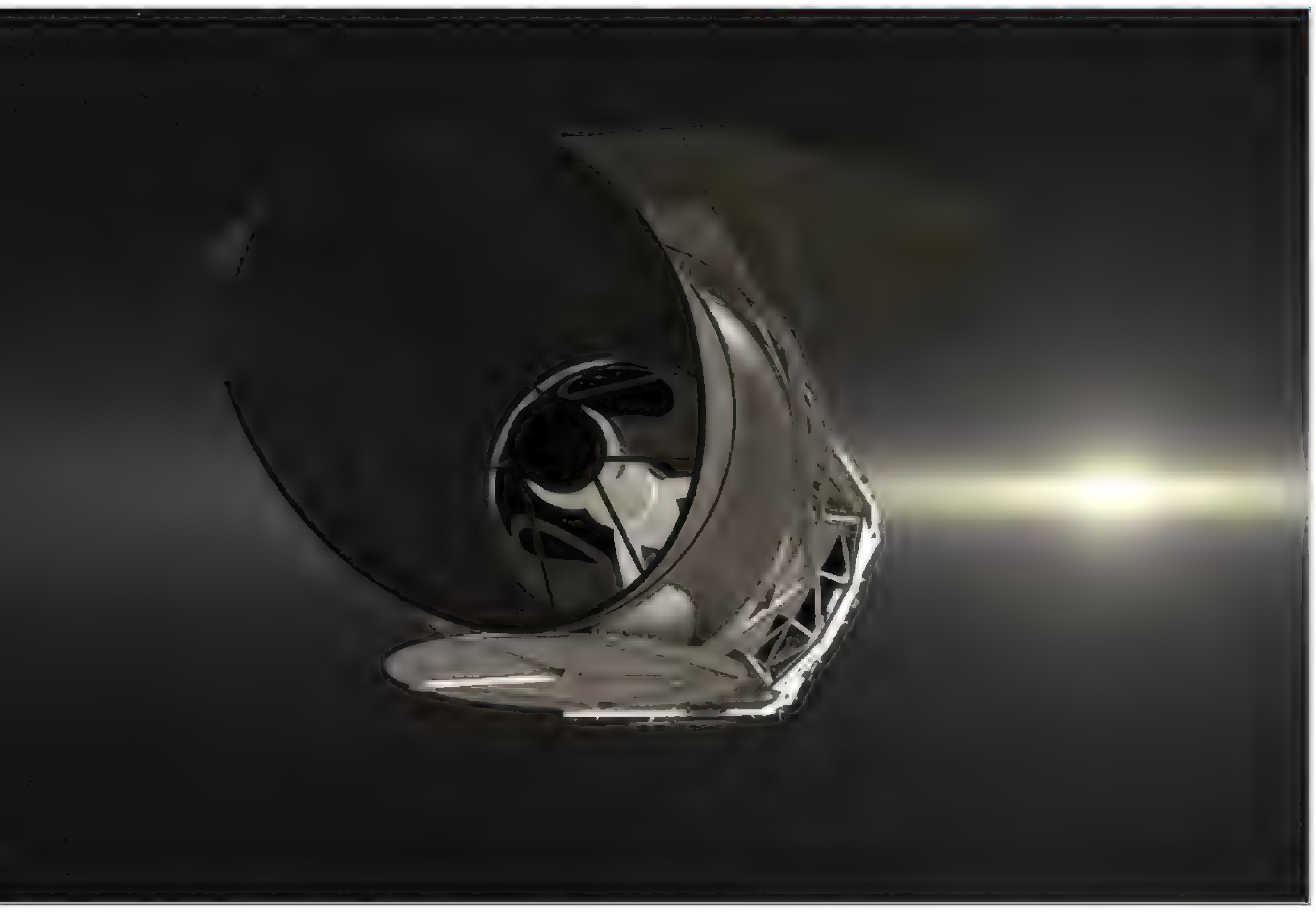
Astronomers have struggled to measure the Sun's magnetic field, as the Sun is too bright for most telescopes. The observatory which made the discovery – the Swedish Solar Telescope in La Palma – can only focus on 1 per cent of the Sun's disc at a time. However, on 10 September 2017, it happened to be in the right place to observe a powerful flare, allowing David Kuridze from Aberystwyth University to determine our star's magnetic field.

"This is the first time we have been able to measure accurately the magnetic field of the coronal loops – the building blocks of the Sun's magnetic corona – with such a level of accuracy," says Kuridze.

To find out more about the Sun's ever-changing magnetic field and recent trends of solar activity, turn to page 30.
www.isf.astro.su.se

Our experts examine the hottest new research

CUTTING EDGE



◄ **WFIRST, the Wide Field Infrared Survey Telescope, will be launched in the 2020s to detect planet masses**

Filling in the gaps in exoplanet systems

While our searches for distant worlds have been fruitful, there are types that are being left out

Our hunt for planets orbiting other stars in the Galaxy has been successful so far. We've now discovered over 4,000 such extrasolar planets, and the catalogue of known alien worlds gets longer every year. Space telescopes such as Kepler and TESS have been productive in this search, looking for the tell-tale dipping in the brightness of a star as an orbiting exoplanet transits across its disk.

But we are also aware that our knowledge of the full architectures of other planetary systems is incomplete due to the ways that we search for them. The transit method has been highly successful, but mostly at detecting relatively large planets orbiting closely to their star. The radial velocity technique is more effective at detecting planets orbiting further out, but the fact that such worlds can take a decade or more to complete each orbit creates problems. We must ensure that we conduct observations over a long-enough time and that datasets are consistent.

NASA, ESA/ATG MEDIALAB, BRAM VENEMANS

Prof Lewis Dartnell is an astrobiologist at the University of Westminster and author of *Origins: How the Earth Made Us* (geni.us/origins)

So we know lots of near-in planets, but not as much about possible siblings further out in these planetary systems. This is a problem for a number of reasons. Firstly, to improve our understanding of how planetary systems form and evolve over time we need a complete picture of both inner and outer planets – theories can only be refined or refuted based on observations. Secondly, the presence of outer planets can influence the habitability of inner rocky worlds like Earth, such as by affecting how much water they form with or how often they are hit by large impactors. This is why David Bennett, at NASA's Goddard Space Flight Center, and his colleagues argue that we need more effort to find these more distant planets. Luckily, says Bennett, there are a number of missions that ought to be able to provide this missing information.

WFIRST (Wide Field Infrared Survey Telescope), for example, was approved for development and launch in 2016. This space-based telescope will use microlensing – detecting the mass of unseen planets and stars by the gravitational lensing effect they have on brighter stars behind them – to find planets in a wide range of orbits from their suns. WFIRST will be over 100 times more sensitive than other methods, and should also be able to detect exomoons in systems similar to that of our own Earth and Moon.

We know lots of near-in planets, but not as much about possible further out siblings in these planetary systems

There's also a mission already operational that can provide this crucial information on wide-orbit planets. ESA's Gaia space telescope was launched in 2013 and has been measuring the positions of millions of main sequence stars in our Galaxy. By 2023 it is hoped that tell-tale cyclical wobbles in these stellar positions, known as the astrometry method, will reveal tens of thousands of new planets, out to 5 AU from their star.

By combining these different datasets, Bennett says we'll be able to add wide-orbit worlds to our planetary demographics and finally produce a complete picture of the architectures of diverse planetary systems.

Lewis Dartnell was reading... *Wide-Orbit Exoplanet Demographics* by David P Bennett et al. **Read it online at arxiv.org/abs/1903.08187**

Sharpening the distant Universe

ALMA is allowing astronomers to image far away galaxies in more detail than ever before

Studying galaxies in the early Universe can be a thankless task. While those of us who study local systems get beautiful pictures which grace magazines like this one, peering at faint light from distant systems can be little more than 'blobology'. This month's paper, though, reveals one such system in all its glory.

Light from the galaxy in question, J0305-3150, has been travelling towards us since the Universe was less than a billion years old, revealing a glimpse of the early days. That light was captured by ALMA, a scope set high up in the Chilean Atacama Desert, which is sensitive to what astronomers call 'sub-mm' radiation; the light that was emitted in the visible or even the infrared region of the spectrum has been shifted all the way to the sub-mm region by the expansion of the Universe.

Longer wavelengths normally mean poorer resolution, but ALMA is an interferometer, combining light from different dishes to build up a sharper image than any single dish could ever achieve. That's why I'm excited by the image which, though still somewhat blobby, looks like a galaxy. Transport this galaxy to the present day, though, and it would stand out. It is forming stars at a prodigious rate. The observations show that J0305-3150 is turning 1,500 solar masses of gas and dust into stars each year, compared to a measly one to three solar masses in the Milky Way.

Moreover, the real action is at the galaxy's centre. Here, a black hole weighing in at a billion solar masses lurks. The hot gas falling towards it shines brightly, making this galaxy host to a quasar – a bright source of light at its centre.

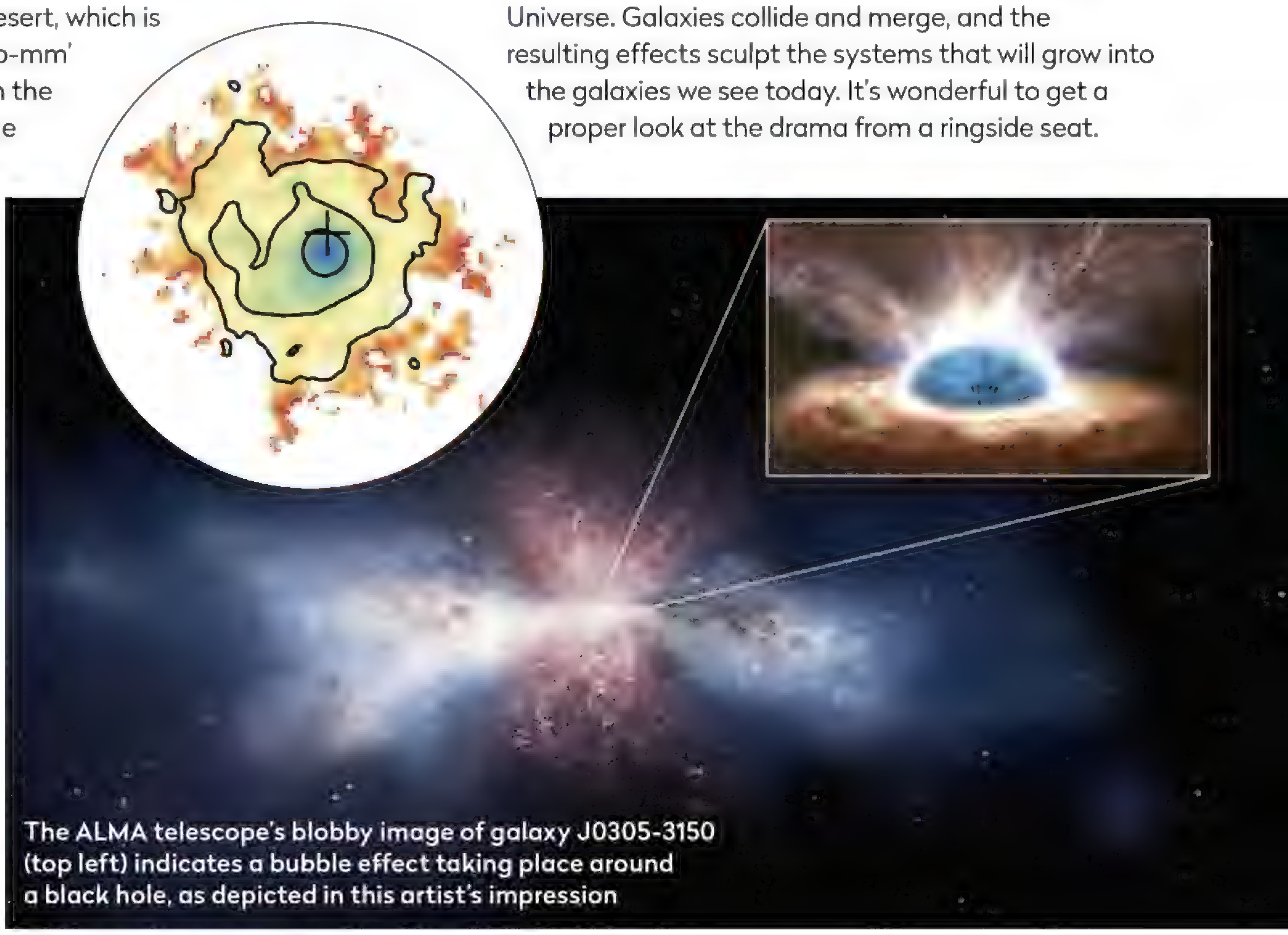
Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also director of the Zooniverse project

Peering at light from distant systems can be 'blobology'. This month's paper reveals one such system in all its glory

Using ALMA to map the central region reveals how this activity around the black hole is affecting its surroundings. Gas is sculpted into odd shapes, with large bubbles or cavities appearing within the central 10 lightyears. What's strange is that these holes are not centred on the black hole, but are offset. This makes it difficult to blame the black hole for what is seen, but the alternative hypothesis, of several hundred million supernovae in more or less the same place over the course of 40 million years is hard to fathom.

Another mystery is why the system is in such a state of frenzied activity. One possibility lies in the discovery of three new sources, which seem to be companion galaxies, at the same distance as the main host. They are fainter, no more than a tenth as luminous, but gravitational interactions with such satellites may have kicked off the burst of star formation and fuelled the central black hole.

This is what life is like in the first billion years of the Universe. Galaxies collide and merge, and the resulting effects sculpt the systems that will grow into the galaxies we see today. It's wonderful to get a proper look at the drama from a ringside seat.



The ALMA telescope's blobby image of galaxy J0305-3150 (top left) indicates a bubble effect taking place around a black hole, as depicted in this artist's impression

Chris Lintott was reading… *400 pc imaging of a quasar host galaxy at z=6.6* by Bram Venemans et al. **Read it online at arxiv.org/abs/1903.09202**

INSIDE THE SKY AT NIGHT

The InSight mission's first selfie on Mars, taken on 6 December 2018 by a camera attached to a robotic arm

April's *Sky at Night* episode looked at what the InSight mission will tell us about Mars's interior. Seismologist **Anna Horleston** reveals how the lander's equipment is peering inside the Red Planet

▲ A Martian view, taken by the InSight lander on 22 March, shows the mission's seisometer (SEIS) under its dome-shaped shield

On 19 December 2018 NASA's InSight lander placed SEIS, its six-component seismometer, onto the surface of Mars. On 4 February 2019 SEIS was covered by a wind and thermal shield, protecting the sensitive instrument from Mars's 95°C daily temperature swings and creating the environment for listening to every little vibration from the planet.

SEIS contains two different seismometers. Three components are designed and built in the UK. Etched from silicon wafers, these are optimised to record high frequency signals and are ideal for detecting local earthquakes and meteorite impacts. Three other components, designed and manufactured in France, are tuned to measure longer period waves associated with larger earthquakes, tidal effects and planetary resonances. The combination – of sensors designed to pick up short and long duration signals – makes SEIS capable of monitoring a wide range of seismic activity.

By placing SEIS directly onto the surface of Mars and by protecting it from wind and temperature changes, InSight has removed many of the constraints the Viking missions' seismometers encountered. Their seismometers were on each Viking lander's deck and mostly detected wind vibrations. SEIS is performing exceptionally well and is now entering the monitoring phase where we will seek out seismic events and meteorite impacts.

Learning from Earth

But why put a seismometer on Mars? Well, because the vast majority of our knowledge of Earth's interior comes from seismic data. Seismic signals are interpreted, a bit like MRI scans, to identify layering and compositional changes within the Earth. Seismometers are the best probes for understanding the interior of planets, but they are not the only instruments we have sent with InSight. The mission also has a temperature probe (HP3) designed to

NASA/JPL-CALTECH X 3, ESA, ESA/MPAE LINDAU

Dr Anna Horleston is a planetary seismologist at the University of Bristol, and member of the international MarsQuake Service

burrow as deep as 5m to measure the heat flow out of the planet and a radio positioning experiment (RISE) to measure the precise wobble of Mars during its orbit, giving us an idea of the state of the Martian core, solid or liquid.

Mars is often said to be in the 'Goldilocks' zone – the habitable region around our Sun, and yet it is barren and seemingly dead. It once had oceans, liquid water and an atmosphere; there is the largest volcano in the Solar System and huge canyons run across its surface. And yet now the planet appears to be dusty, dry and cold with almost no atmosphere. Understanding the interior of Mars will tell us about the evolution of the planet and how it is so different from Earth, and it will give us clues as to where else in the Galaxy we might find habitable planets.

It is still early days for InSight, but the seismometer is perfectly deployed and has detected many atmospheric effects including signals from vortices (dust devils) and atmospheric pressure waves. The MarsQuake Service, an international team of seismologists led out of ETH Zurich and including members from France, the US and the UK, is fully operational, scanning the seismic data as soon as it arrives. After four months, I'm still amazed every day when I see new data from another planet.

Looking back: The Sky at Night

May 1986

On the 25 May 1986 episode of *The Sky at Night*, Patrick Moore looked at the latest results from the Giotto spacecraft, which flew past Halley's Comet on 14 March that year.

The comet orbits around the Sun once every 75 years, and in 1986 it passed through the inner Solar System – the first such close approach since the start of the space race. To take advantage, an armada of five spacecraft was launched to explore the comet, including ESA's Giotto.

The spacecraft passed just 1,373km from the comet nucleus. At this distance, it was bombarded by dust from the comet, and one large impact sent the spacecraft spinning just 7.6 seconds before closest approach. Thankfully, Giotto recovered, and was able to take the first close-up images of a comet nucleus, revealing the comet as peanut shaped and roughly 15km in length.

Giotto analysed the composition of Halley's Comet, finding it was largely the same as the solar nebula. This implied it was a primitive body that had remained relatively unchanged since the beginning of the Solar System.

▲ **Giotto (inset) unlocked mysteries about the size and shape of Halley's Comet**

Supermassive Black Hole

It is thought that there is a supermassive black hole at the centre of almost every galaxy, including our own. This month the *Sky at Night* team look into Sagittarius A*, the supermassive black hole at the Milky Way's centre, to discover what astronomers know about it. Plus, they reveal the first ever direct image of a black hole, newly captured by the Event Horizon Telescope.

BBC Four, **12 May,** 10pm (first repeat
BBC Four, **16 May,** 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times

▲ **A supermassive black hole lies buried at the core of the Milky Way**

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Defying light pollution

▲ **For his Orion Nebula image, James stacked 619 (25-second) exposures, plus 120 dark, 120 bias and 100 flat frames using Astro Pixel Processor**

I live in just about the worst location for anyone interested in astronomy and astrophotography, which is Birmingham. My house is 5km from Birmingham International Airport and the National Exhibition Centre (NEC). The light pollution levels are among the highest in the UK, possibly even in Europe generally. For years, I had fooled myself into thinking that the light pollution of our major cities meant that astrophotography was probably an exercise in futility, but last year I decided to see what could be achieved. I got this image of the Orion Nebula, taken over five nights in February, using a Canon EOS 5DSR at the prime focus of a Vixen 105mm refractor on a guided equatorial mount. It is definitely not the best image ever captured and is probably the best I can hope to achieve given my location, but it most definitely gives me a buzz having got this result. I suppose the lesson is to just have a go and see what is possible.

James Edwards, Birmingham

Well done James, it's heartening to see what can be achieved even from one of the most brightly-lit places in the UK! – ***Ed***

Tweets

Stuart Hough
@Stutree • Mar 21
Helped a lovely guy today to set up his telescope, our newest member @AstroBrighton Ken is 101 and he used to train pilots during WW2 to navigate using the stars! Wanted a telescope to look at the moon, but not the best! @JPMajor @skyatnightmag @AstronomyMag @VirtualAstro

South Island sights

We were lucky enough to spend three weeks touring New Zealand's South Island earlier this year. It's a fantastic location for casual stargazing. When planning our holiday we did consider taking a small scope but decided against doing so on weight grounds. However, we were lucky

enough to see the sights of the southern skies most nights, using nothing more than our own eyes. The view of the southern Milky Way (below) was taken at the easily accessible location of Lake Pearson just off Arthur's Pass; a fantastic place for stargazing – and the wine there isn't too bad either.
David Palferman, Tattenhall

Glory days

Can someone explain why nearly all NASA missions have expected lifespans of time measured in days rather than years? For example, the Opportunity rover's lifespan on Mars was 90 days; and Voyager was a little longer, but still just five years. Yet Opportunity lasted 15 years and Voyager so far has lasted well over 30 years. It's the same with many other Mars rovers and planetary missions – all lasting hundreds of times longer than expected. Why is that?
Philip Coates, Accrington

Rocket science

We use rockets to launch satellites and cargo to space, which is like using a 50-tonne lorry to transport 1 cwt (hundredweight; 50.8kg). Most of a rocket's mass is fuel; very little is cargo. In the 1960s, the US and Canada developed Project HARP, using a 16-inch naval gun to test ballistics. Did the brains behind it, Canadian engineer Gerald Bull, ever consider using the recoilless ▸

ON FACEBOOK

WE ASKED: What is your favourite astronomy accessory?

Richard Leighton
My elastic band to stop my telephoto lens retracting.

Mick Cassidy
My Wixey angle gauge: basically a digital level. It's magnetic and sits under the front of the finderscope of my Dobsonian. Makes looking for deep sky objects a lot easier.

Peter McNulty
A Pentax zoom eyepiece 8-24mm.

Brendan Scoular
A binoviewer. It's good at fooling the brain into making the object appear 3D. Also, with two eyes open you can tease out more detail on the planets, like Jupiter's belts and zones.

Rav Langotr
My Polemaster. It's a great tool to get an accurate polar alignment in a short time without the pain of getting stiff neck and knees looking through a polar scope.

Roy Alexander
I've tried a few different gloves and the best I've found are my Cashmere lined Italian leather gloves which give the best warmth/digital dexterity ratio.

Michael Landon
My eyes, as I can see a lot more of the sky than looking through a scope; followed by my binoculars.

Gillian Rushforth
A 32mm good-quality eyepiece. I start any observing session with one of these because you get the wide-field experience of viewing and it gets you oriented in the sky, so you can then move on to higher magnitude ones and more specific targets

David Jones
An umbrella

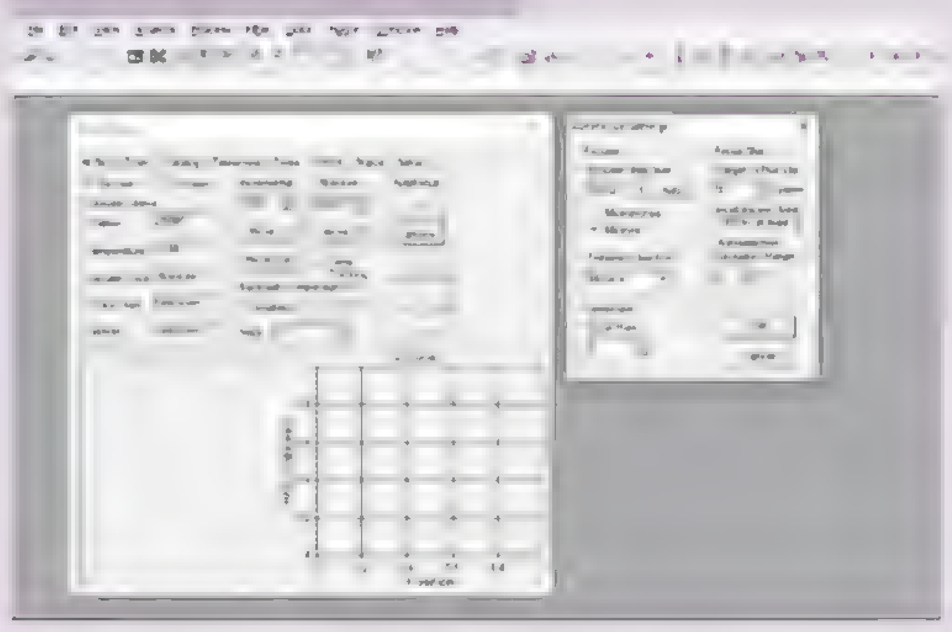
Stephen Webber
My mate's car boot. It takes all my kit when we go out to observe dark skies.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I'm having trouble setting up MaxIm DL software for autofocusing. Any advice?
ROY PLENTY



▲ **Get your facts straight: the MaxIm DL Autofocuser equipment settings need to be accurate**

MaxIm DL is a powerful image capture program, but the key to getting the autofocuser routine to work well is ensuring that the equipment settings are accurately entered.

The system needs to know how far your focuser moves for one step of the focus motor, so select View – Observatory Control Window – Focus. With the focuser set at half its extension, enter 100 in the Incremental box and then click on the 'Move In' button to take up any backlash. When the motor stops, measure the extension of the focus tube from the focuser housing in millimetres. Next, enter 1000 in the Incremental box and click on the 'Move In' button. Re-measure the extension and calculate the distance moved in millimetres. Click on the 'Options' button and enter this value in the Focuser Step Size box – never use the 'Auto' button. Select the Microns radio button and enter your telescope's focal ratio in the box. In the Target ½ Flux Dia. box enter a value between 7 and 9 as this sets a higher than desirable focus target. This is required as the measurements are made on either side of focus, not at focus.

Steve's top tip

What is a guidescope?

A guidescope is used to correct for small errors in a mount's tracking. The guidescope is a small refractor or even a modified finderscope that is mounted along with the imaging telescope and camera and its job is to capture an image of a single star using its own small camera and then to analyse the movement of that star in the field of view using guiding software. If the star moves, the software sends corrections to the mount to 'keep it on track'. Because the guidescope and imaging scope are mounted together, corrections in the guidescope produce matching corrections in the imaging scope.

Steve Richards is a keen astro imager and an astronomy equipment expert

STEVE RICHARDS

BBC Sky at Night MAGAZINE

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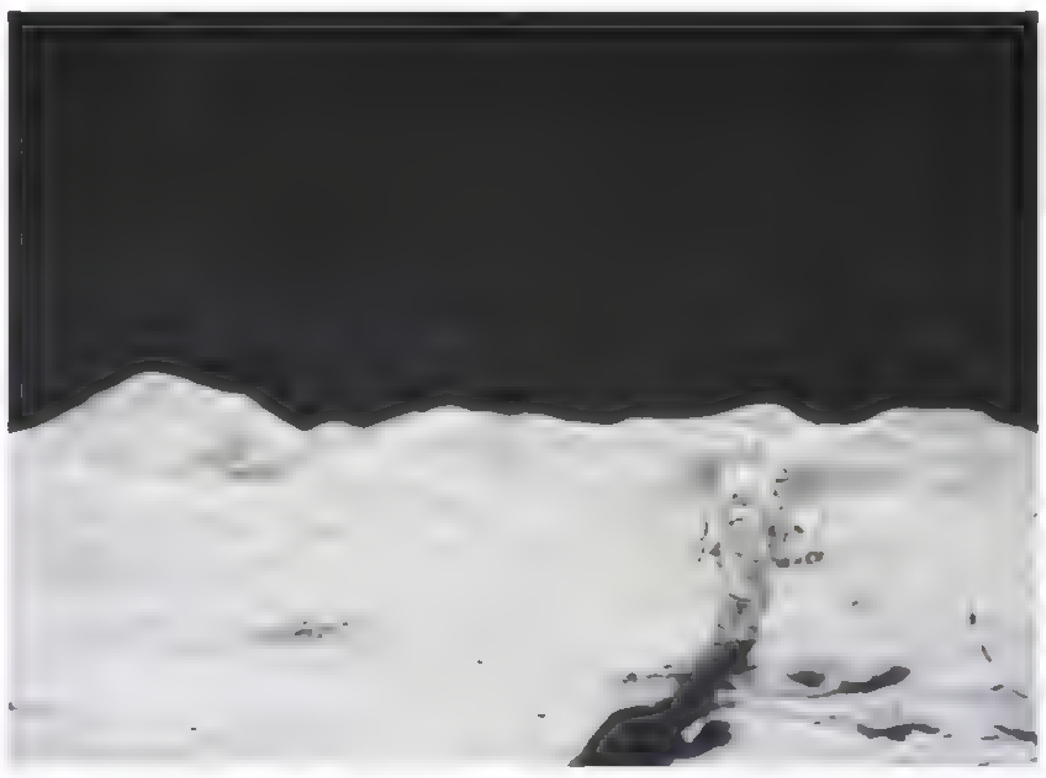
▸ gun principle to launch a satellite? Rockets are like the propeller in the 1930s; there must be something better.
John G Phimister, Kirkcaldy

Smashing plates

Earth is the only planet we know so far that has plate tectonics, a process which some believe began around 4 billion years ago. Is it possible that the Earth's collision with Theia, or another external body, could have triggered the initiation of fracturing across Earth's surface?
David Mayston



Rille seeker

Your recent items on the Apollo missions prompted me to send in this mixed media picture of Dave Scott at Hadley Rille. It's a pencil drawing with watercolour highlights. I am fascinated by all aspects of the Moon and enjoy observing and photographing it, as well as drawing it.
Andy Bucknell, Doncaster

And finally...

Here's a joke you may like. Did you hear all the seats for the end of the world are sold out.
So it's expanding gloom only.
Tom Mexbass, via email

Tweets

Jeremy Flint
@JeremyFlint50 • Mar 20
@skyatnightmag 67P/ Churyumov-Gerasimenko #potato

SOCIETY IN FOCUS

Recently, on a bright St Patrick's Day, Southport Astronomical Society opened the Hesketh Park Observatory to the public. The park and observatory are both Grade II-listed, both having recently celebrated their 150th anniversaries.

For many years the dome was located at the home of Joseph Baxendell in Southport. A meteorologist, in 1871 he relocated his family to Southport to manage a newly built weather station in Hesketh Park. He used the telescope to detect variable stars and was elected a Fellow of the Royal Astronomical Society and the Royal Society.

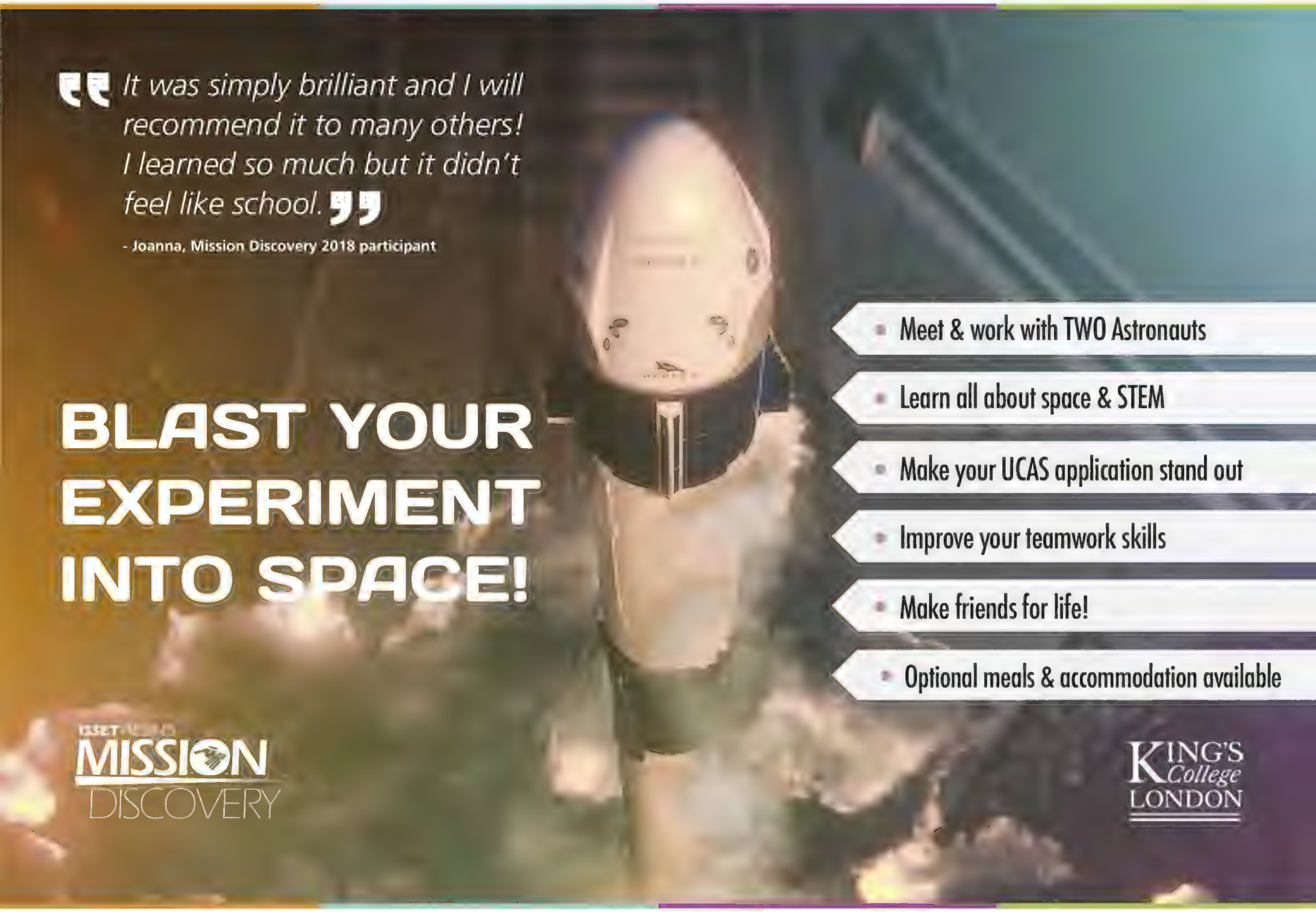
The telescope is a 6-inch achromatic refractor with a focal length of 90 inches. Manufactured in 1869 by Thomas Cooke & Sons of York, it is the only one of its type to retain the gravity -powered mechanical drive system with which it was fitted.

The observatory was opened to the public in 1901, when local dignitaries were among the crowds attending. Our recent open day was also busy, with queues to get in. Visitors were shown the interior by society members who explained the operation, history and purpose of the telescope, and answered countless questions. In total, 167 visitors came, including 65 young people, to enjoy a novel experience that stirred their minds.
Robert Mount FRAS, Southport Astronomical Society. www.southportastro.org

Mission Discovery Space & STEM Camp

Team-up with TWO Astronauts & launch your experiment into space

Students aged 14-18 can meet and work with Astronauts Michael Foale (left) and Tony Antonelli (right) for 5 days at ISSET's Mission Discovery programme, hosted at King's College London **8th - 12th July 2019** and compete to launch an experiment they design into space to be carried out by astronauts aboard the International Space Station!



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Our pick of the best events from around the UK

WHAT'S ON

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Visit our website at **www.skyatnightmagazine.com/whats-on** If you want to tell the world about your event, fill in the online submission form

Apollo 10 anniversary dinner

National Space Centre, Leicester, 18 May, 6.30pm

Join special guests for an Apollo-themed dinner to mark the 50th anniversary of the Apollo 10 launch, including a Q&A and documentary screening. Tickets are £50.

www.spacecentre.co.uk

Shrinking Mercury

Royal College, Strathclyde University, Glasgow, 16 May, 6.45pm

The Astronomical Society of Glasgow gives a guide to the visible objects in the night sky, followed by a lecture from Dr Simon Cuthbert on how Mercury is shrinking.

www.theasg.org.uk

Family planetarium shows

Armagh Planetarium, County Armagh, May

During May there is a range of shows at the planetarium, teaching pre-school children about the planets and taking adults and young astronomers on a Solar System tour.

www.armagh.ac.uk

Bath astronomers

Wellow public car park, Wellow, Nr Bath, 2–5 May (weather depending), 9.30pm

One stargazing session will take place during 2-5 May, so check the group's Facebook page or visit their website.

www.bathastronomers.org.uk

GRIMSHAW ARCHITECTS/NATIONAL SPACE CENTRE/LEICESTER/®HUFTON/CROW, SDSO

PICK OF THE MONTH

▲ The SDSO's hillside setting gives visitors access to some of the UK's best dark skies

Stargazing under Scottish dark skies

Scottish Dark Sky Observatory, throughout May

The Scottish Dark Sky Observatory (SDSO) is located on a hilltop on the edge of Galloway Dark Sky Park and operates under some of the darkest skies in the UK.

As the summer approaches and the nights get shorter, you can take advantage of the pristine sky conditions at one of the observatory's many stargazing sessions held over the month.

Each session begins at 10pm and involves an evening of guided stargazing with expert astronomers, as well as viewing the night sky through the observatory's telescopes. The event also involves an introductory astronomy talk and a tour of the observatory.

This month, stargazing events are being held every weekend as well as both bank holidays. Sessions are suitable for newcomers and seasoned observers, young and old alike. Tickets are £16 for adults, £12 for concessions and £10 for children. As observing sessions are weather-dependent, always check with the observatory before beginning your journey. More information can be found on the SDSO website.

scottishdarkskyobservatory.co.uk

Telescope tour

Grizedale Forest, Lake District, 4, 12, 24, 25 May, 8.30/10pm

Astronomer Robert Ince presents a telescopic tour of the constellations and the Milky Way, plus lessons in how to navigate the night sky for yourself. Tickets are £15.

www.eventbrite.co.uk/o/robert-ince-7214874047

Stargazing in central Wales

Newtown Catholic Church, Long Bridge Street, Newtown, 11 May, 7pm

Newtown Astronomical Society meet for some telescope surgery, stargazing and a talk on music in astronomy. The event is £3.50 for visitors, free for under-16s.

www.facebook.com groups/1412459148966189

GLAMPING WITH THE STARS

Here's a great selection of places to stay where you can relax in comfort and enjoy the experience of a dark sky above

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www.ruberslaw.co.uk

SEREN

Nestled in the corner of a field, this whimsical hut has everything you need to relax and unwind, with its log burning hot tub to watch the stars, before drifting off in your kingsize bed. Includes private bathroom, hot shower, gas BBQ & fire pit. From £100 a night. **07528 343881**
www. jubileebarn.net

STARGAZING AT KAYA LODGE

At the end of a day spent exploring Suffolk, why not cook up a storm on the BBQ, toast marshmallows or retire to the deck as the stars come out? Stay in our luxurious safari tent and experience the magic of sleeping out with the added comforts of a hot shower and cosy woodburner.
07919405594
www.kayalodge.co.uk

FIELD OF VIEW

Never the twain shall meet?

While astronomy and astrology are clearly poles apart, **Jonathan Powell** discovers a shared passion for the stars

Jonathan Powell is the astronomy correspondent for the *South Wales Argus*

Ask me to talk about astronomy to anyone showing an interest, and I immediately download the classic Patrick Moore delivery technique, high-speed, detailed and wonderfully passionate. My interest in astronomy began at such a young age that no one else was into it, they all preferred football and cricket. And while I followed these sports and still do, I've developed the habit of talking to anyone showing even the slightest interest in the stars as if I was a missionary, enlightening those with time to listen about the stars and planets, and attempting to match my output with anything currently on view in the night sky. A chance to show rather than just talk about astronomy.

Therefore, when a friend of mine said that a newly found mutual friend didn't realise I had such a passion for the stars, I was understandably keen to impart all I could; not to impress, but to show that astronomy is very accessible.

When I've talked to others about the subject over the years, it's been a surprise exactly how many people, of all ages, have an interest in astronomy but have never taken it beyond the point of it just being a casual affair. Their enthusiasm intermittently rekindles upon the arrival of a bright comet in our skies, a supermoon perhaps, or just sighting Venus in the morning or evening sky. One only has to look at the interest shown UK-wide during the last return of Halley's Comet to see how people react to something they can see, rather than just be told about it. It makes a world of difference.

As soon as possible, my newly discovered friend and I met up and, bubbling with excitement, I reeled off a summary of my involvement in astronomy since prehistoric times. As I delivered my keenly expressed words, her eyes lit up and were accompanied by a broad smile – it appeared as if common ground had been reached. Indeed, I thought 'first contact' had been established.

When I had finished delivering my verbal barrage, she replied positively but with a dialogue that included words such as 'zodiac' and 'spiritual'. I realised quickly I had followed the right rabbit but down the wrong hole, as it was astrology she was interested in, not astronomy. Having quickly returned up and out of the hole I'd gone down, the conversation from that point remained pleasant and civilised, but at cross-purposes.

The stars to some mean something completely different to the science of astronomy. However, one must respect the chosen passion, pursuit, and interest that others have, as to them, it is held in the same regard as that which we astronomers invest in our own field.

History tells us that for many ancient civilisations, the two subjects of astrology and astronomy were once very much intertwined, with a great deal of time, care, and attention taken to recording events in the night sky. Coupled with a belief system, this early approach resonated throughout many cultures across the globe.

However, I do recall Sir Patrick's lead weight definition of astrology – "Bunkum!"

JIA-YI LIU/FOLIO ART

Prof Lucie Green is a Professor of Physics at Mullard Space Science Laboratory. She is author of *15 Million Degrees: Journey to the Centre of the Sun*

This montage of 365 images from ESA's Proba-2 satellite shows the low activity of our Sun throughout 2018. At the extreme ultraviolet wavelengths pictured, active regions are shown as bright spots

ESA/ROYAL OBSERVATORY OF BELGIUM

Are sunspots really in DECLINE?

Lucie Green reveals how the science of the Sun's magnetic heartbeat explains a drop in solar activity

The number of sunspots observed on the solar surface follows a roughly 11-year pattern of peaks and troughs known as the solar cycle. I started my career in solar physics in cycle 23 and we are currently coming to the end of cycle 24. While we still have a lot to learn to accurately estimate the patterns of future solar cycles, predictions over the past decade suggested that our current cycle would be smaller than average. Does this mean an overall waning of solar activity? New research over the coming years may help us get a better idea of what the future holds for our host star.

Sunspots have been observed for thousands of years, even before the development of the solar telescope provided a way to safely view our dazzling local star. Systematic records of sunspot numbers and their positions didn't begin, though, until the mid-1800s. Still, these records represent the longest running dataset of any cosmic phenomenon and reveal an intriguing side to the Sun's character.

That the solar cycle was ever noticed is thanks to astronomers spurred on by the possibility of discovering a new planet. In 1846 Neptune had been discovered in the search to understand whether irregularities in the orbit of Uranus were due to problems with Newton's theory of gravity, or the gravitational effect of a then undiscovered planet. The latter idea won. So when irregularities were discovered in Mercury's orbit, it seemed only sensible to take the same approach and the existence of ▸


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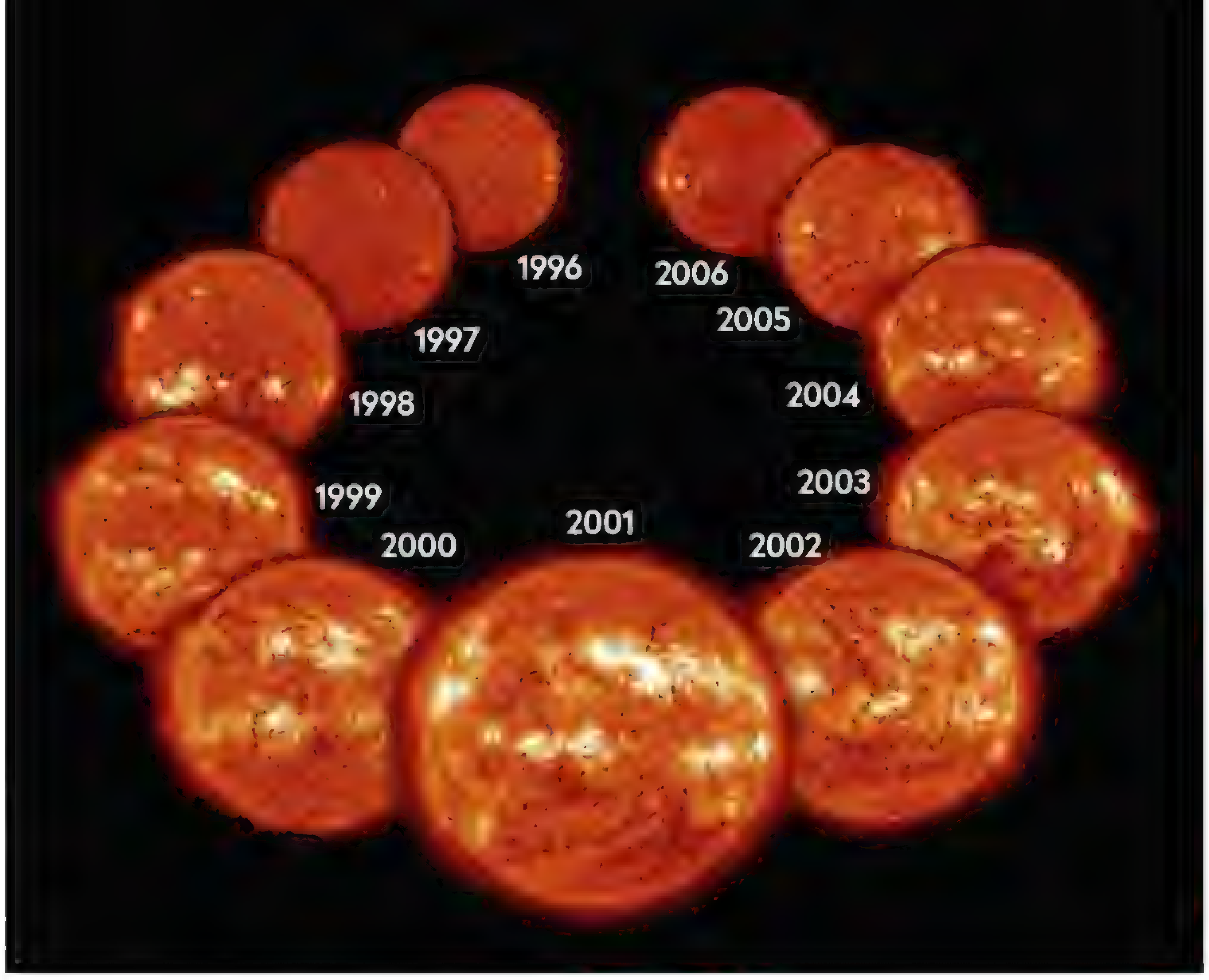
▸ the planet Vulcan orbiting close to the Sun was proposed. The theory could be tested observationally by looking for the planet as it transited the Sun.

One person who took up this challenge was German pharmacist-turned-astronomer Heinrich Schwabe, who observed the Sun every clear day from 1826 to 1843. Although he found no evidence for the hypothetical planet Vulcan, his sunspot records did reveal a 10-year period or so during which their numbers rose. A repetitive process seemed to be at work. Soon astronomers across Europe were being encouraged by the director of Bern Observatory – Rudolf Wolf – to make regular observations of the Sun and record their findings. Wolf combined the new sunspot records with those taken in the centuries before and was able to reconstruct sunspot cycles back to 1755. He called this 'cycle 1' and numbered all the following cycles consecutively.

What causes sunspots?

Solar cycle studies focused for many years on data collection, such as sunspot number, location and shape, until the true origin of sunspots was shown by George Ellery Hale in 1908. Hale discovered that these dark spots on the Sun are actually the intersection of colossal tubes of magnetism penetrating the photosphere. This discovery started a revolution in solar physics and showed us that the solar cycle is actually a magnetic one.



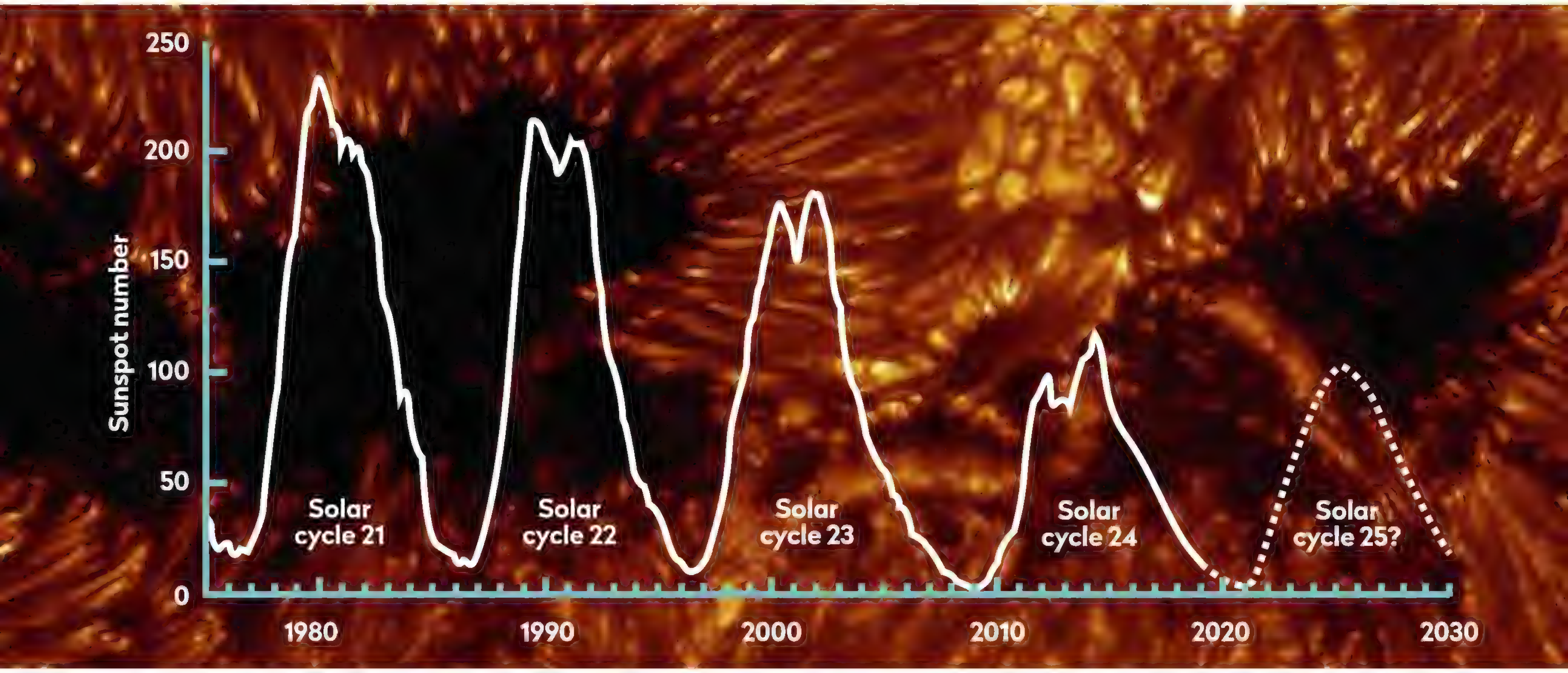
▲ Solar cycle 23, captured in extreme ultraviolet light by NASA's SOHO spacecraft, reveals maximum activity in 2001

Today we understand that flows of electrically charged gas inside the Sun both sustain and evolve the global magnetic field. The solar cycle captures all the stages of this evolution. At the start of the cycle, the Sun's global field is aligned in a north-south direction. The flows then drag out this field so it becomes more aligned with the east-west direction. When portions of the interior field grow too strong, they become buoyant and a loop rises to penetrate the Sun's surface. Sunspots form at the two foot points of the loop: one sunspot with a south magnetic pole next to a spot with a north pole. Just like the configuration of a magnet.

The fluid nature of the Sun means sunspots don't live forever. The solar cycle progresses because flows at the surface of the Sun start to tear apart the magnetic fields of the sunspots, spreading the field over ever-larger areas. As the field disperses, the sunspots disappear. Eventually, more fluid flows take the magnetic field up towards both poles of the Sun where it gets reprocessed, ready to feed into the next cycle.

Overall, the evolution of the Sun's magnetic field that drives the solar cycle might seem straightforward.

OBSERVATIONS: GÖRAN SCHARMER/ISP/ IMAGE PROCESSING: MATS LÖFDAHL/ISP, SOLAR CYCLE ILLUSTRATION: PAUL HIGGINS, GLEISSBERG CYCLE ILLUSTRATION: PAUL WOOTTON, SOHO (ESA & NASA)

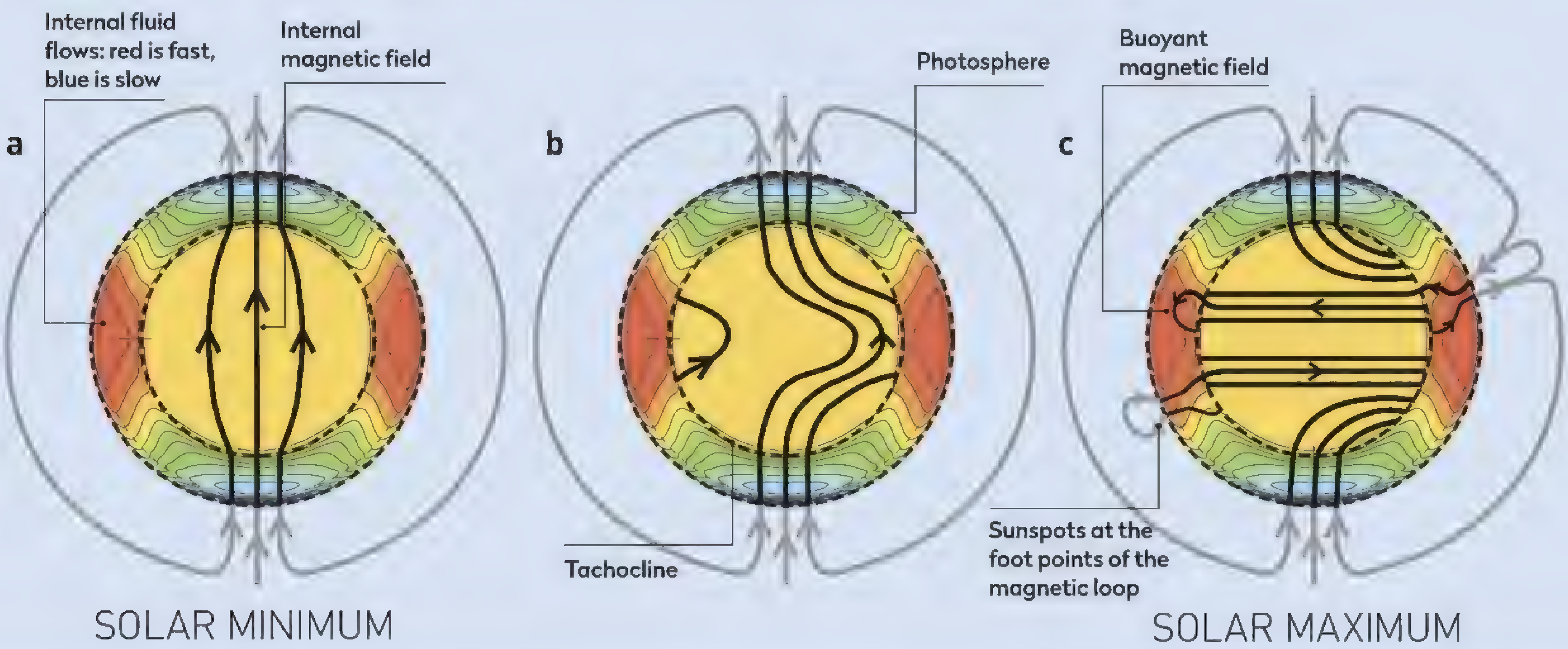


▲ Looking back at recent solar cycles reveals a decline in sunspot numbers. Early indications suggest this trend is likely to continue in cycle 25

How the solar cycle works

This diagram reveals the inner workings of the Sun during the solar cycle. The magnetic field evolves from being aligned north-south at solar minimum (a) to aligning east-west (b), and eventually being multipolar at solar maximum (c).

The photosphere is the visible layer of the Sun that we are familiar with, where sunspots are formed; the tachocline is a region inside the Sun where the magnetic field gets distorted and moved.

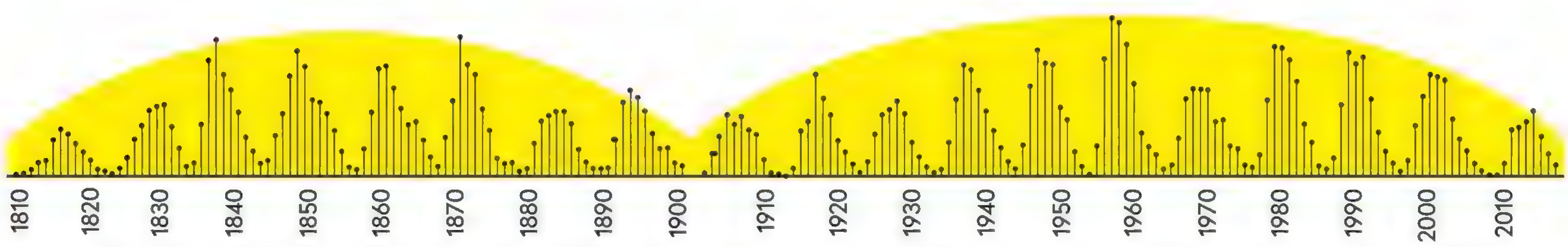


But consider this: cycles can be large or small, and cycles of different sizes do not follow each other at random. Instead, a few large cycles will be followed by a few small cycles. Analysing this trend has also revealed an 80-year so-called 'Gleissberg cycle' on top of the 11-year cycle. And on top of this are the 200-year de Vries and the 2,300-year Hallstat cycles too. Developing a model that can explain all these details is an important area in modern solar physics.

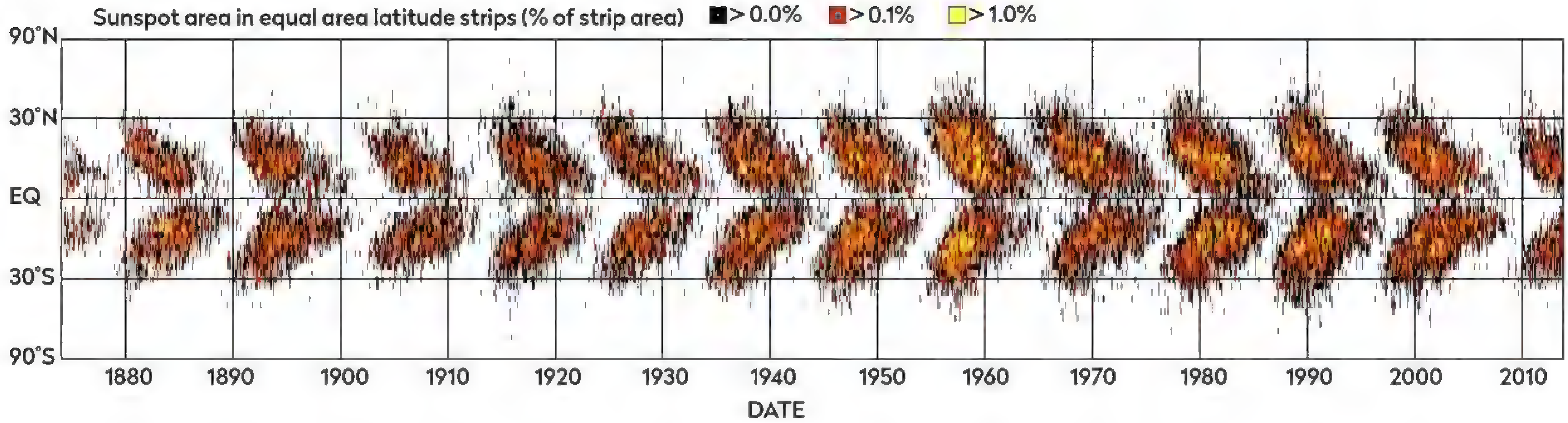
The discovery of the Sun's magnetism was also key to understanding the violent side of the Sun's character: solar flares and coronal mass ejections (CMEs) driven by colossal releases of energy stored in the solar magnetic field. The frequency of solar flares and CMEs peaks at the apex of each solar cycle, as does the amount of light that the Sun emits. At cycle maximum, with the most sunspots, the Sun is fraction of a per cent brighter.

Certain rules are obeyed during a solar cycle. Sunspots appear at high latitudes at the start, with the sunspots that form during subsequent years appearing at progressively lower latitudes. This pattern is shown wonderfully clearly in the so-called 'butterfly' diagram published by astronomers Annie and Walter Maunder in 1904 (see page 34). When pairs of sunspots appear, one with a north pole and one with a south, sunspots in each hemisphere will nearly always appear in the same order as the Sun rotates. For cycle 24, pairs of sunspots in the northern hemisphere that came into view as the Sun rotated had the south pole spot appear slightly ahead of the north. In the southern hemisphere, it was the opposite way round. This swaps every solar cycle, meaning you can use the magnetic field of sunspots to determine which cycle they formed in. The rules apply to the overall global field of the Sun too, and at the peak of each cycle the polar magnetic fields swap their magnetic polarity.

All this prompted the American National Oceanic and Atmospheric Administration and NASA to form ▸



▲ **The 11-year solar cycle (shown here as black lines) can be further grouped into 80-100 year Gleissberg cycles (shown here as a yellow arc) as seen when we look back at the last 200 years of sunspot data**



▸ a 'Solar Cycle 24 Prediction Panel' to see what models and theories are best able to predict solar cycle size, duration and peak.

Making predictions

Prediction methods vary. One uses the finding that the number and frequency of sunspot formation at the start of a cycle is linked to the size and timing of that cycle's peak. Another assesses the strength of the polar magnetic field, that is the 'seed' from which each cycle grows. Another looks at the strength of the gas flows that ultimately drive the cycle. Yet, another approach is to consider solar activity over timescales much longer than a single 11-year cycle.

The challenge is that it is easier to forecast once the sunspots of a new cycle have started to appear. Then the rate at which the sunspots are forming can be compared with that of previous cycles to get an idea of how the new cycle will play out in terms of size and duration.

Initial predictions for cycle 24 came in 2006, even before the first sunspots of that cycle formed. Solar minimum – when the number of sunspots is lowest – was forecast for March 2008 with a moderately large maximum in 2011. In January 2008 the first sunspots of the cycle were seen and by 2009 there were enough to be used in cycle prediction methods. A revised statement from the Solar Cycle Prediction Panel followed in May 2009, downgrading the forecast to a smaller than average cycle that would peak in May 2013. Another slight downgrade came again in 2011. At this time the solar physics community was feeling pessimistic about the status of the Sun's cycles, with some even suggesting that in the coming decades we might experience a strong downturn of the type seen in the Maunder Minimum,

▲ The 'butterfly' diagram shows the latitude of sunspot occurrence versus time in years. When pairs of sunspots form, one with a north pole and one with a south, they appear at the same place in each hemisphere

Spying sunspots through history

Astronomical records paint a picture of solar activity, giving scientists today an invaluable glimpse at the Sun's past

GEOLOGICAL HISTORY

Planet Earth creates its own solar record. Scientists can analyse the amount of certain isotopes in deep drilled Antarctic ice cores to determine the impact of solar flares up to 1.5 million years ago. This will, in turn, help to make forecasts about the future of solar activity.

1128

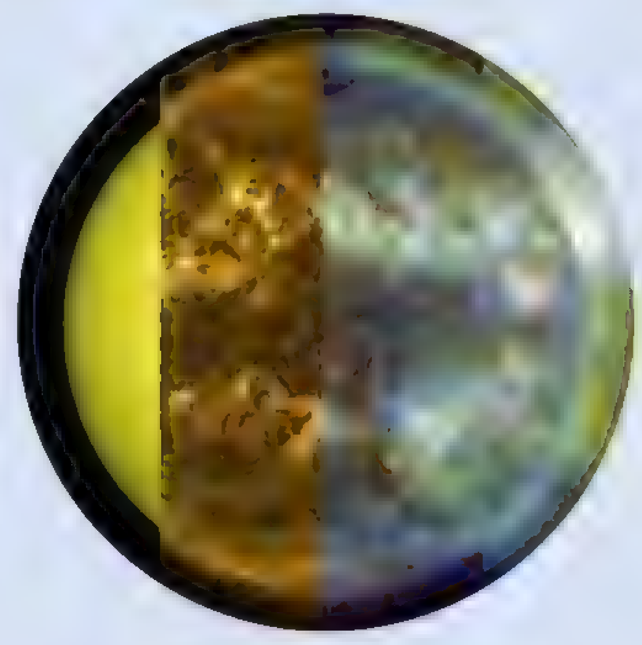
The first-known sunspot drawing, by John of Worcester, who may have observed them through clouds with the naked eye. Arabic, European and Mayan astronomers also observed sunspots, and they were recorded in China over 1,000 years earlier, although no visual records exist.

1612

Galileo was one of the first to systematically observe sunspots, like in this drawing. Galileo began projecting the Sun's image through a telescope in order to study it and surmised that sunspots were features on the surface; a ground-breaking revelation.

1845

The first photograph of the solar surface, captured by Léon Foucault and Louis Fizeau. With an exposure 1/60th of a second, the French physicists created a scientific record of our host star, revealing detail that would be impossible to see with the naked eye.



NOW

Today's fleet of solar telescopes can create multi-wavelength views of the Sun, as this image by NASA's Solar Dynamics Observatory shows. This enables solar scientists to observe the Sun's outer layers, but also peer beneath sunspot areas to get a deeper view of internal solar activity.

A threat to life on Earth?

Predicting irregular solar activity can help to keep us safe

The Sun's evolving magnetic field, along with the associated flares, eruptions and light output, have very real consequences for life on Earth. Flares and coronal mass ejections can create stormy space weather and the varying radiation we receive needs to be fed into climate models on top of changes caused by increasing greenhouse gases.

The solar cycle controls the space environment around Earth. In turn, a range of technological services can be disrupted, from electricity distribution to accuracy of global positioning data and timing information, to the aviation sector and communication networks.

A recent study showed that the magnitude of the solar activity events we have experienced during the last 70 years of the space age might not represent the worst the Sun can do. Around 2,500 years ago a particle radiation storm occurred that was 10 times stronger than anything we have seen: something that, today, we are under-prepared for.

At cycle minimum the Sun's magnetic field diminishes, but Earth is still enveloped in it although we get less protection from harmful particles known as cosmic rays. Predicting upcoming solar cycle sizes and timings enables long-term planning to protect our technology.

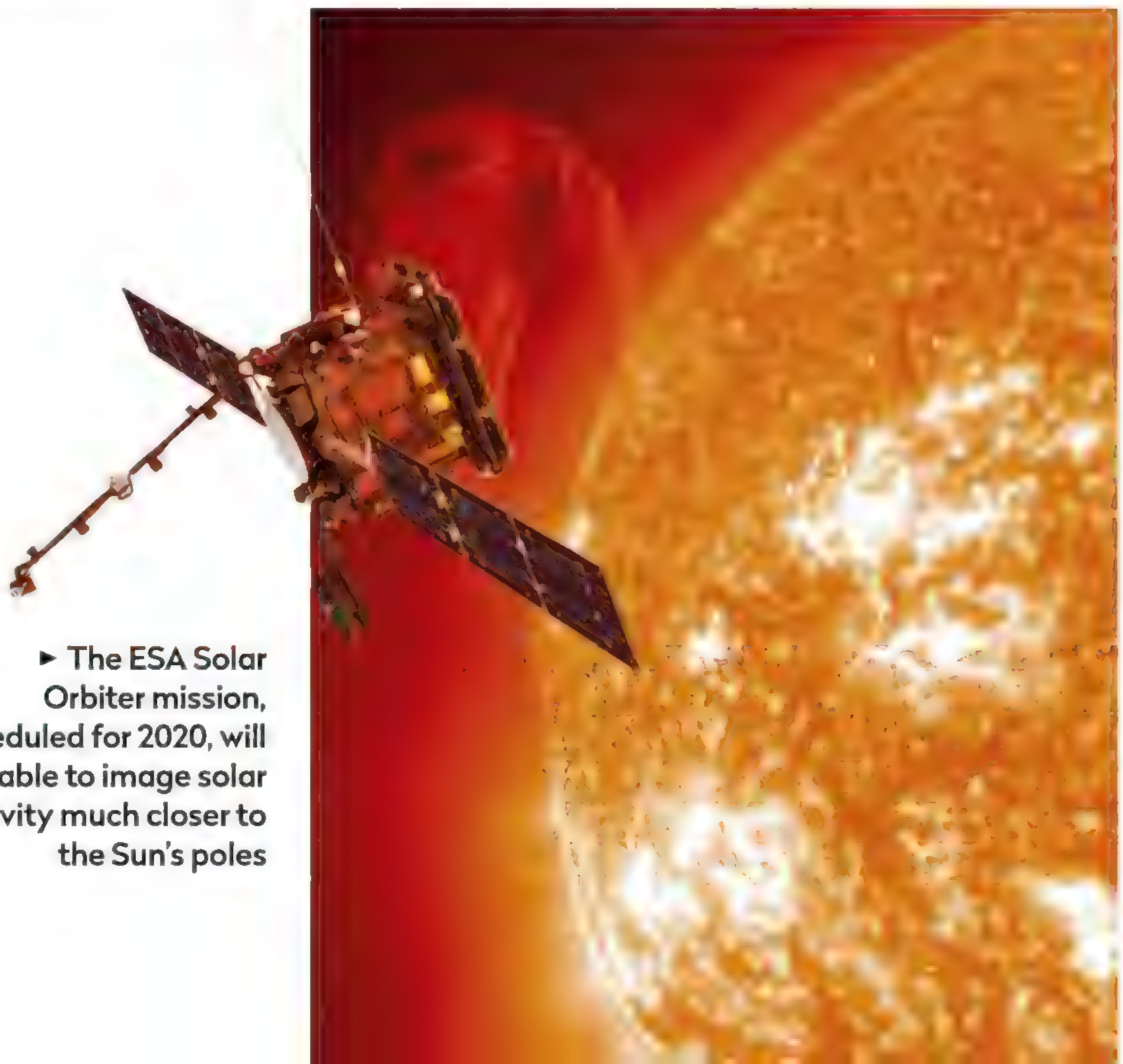
BBC RADIO 4

Listen to a BBC podcast in which Lucie Green looks at solar superstorms and the threats they pose to our planet. **https://bbc.in/2HCgiN7**

when the solar cycle appeared to switch off for several decades in the mid-1600s. If felt like the Sun was fading in front of our eyes.

The Sun eventually reached solar maximum in April 2014 and although the predictions didn't do too badly, it was clear we have a lot to learn. We are now in the waning phase of cycle 24, with a prediction that the cycle won't fully end until well into 2020.

It is never possible to say exactly when minimum occurs until we have passed that point. We need to see the sunspot number drop and then start to rise again with spots that have the new cycle's magnetic field orientation. What we can say, though, is that some very small and short-lived magnetic field bipoles have emerged at high latitudes with the correct, swapped, orientation for cycle 25. However, they never grew into fully-fledged sunspots groups that were officially recognised.



▸ The ESA Solar Orbiter mission, scheduled for 2020, will be able to image solar activity much closer to the Sun's poles

How bright is the future?

What might cycle 25 have in store? Well, the challenges with predictions in previous years have motivated new research. New physical models are being developed along with new analysis of the observations. A recent forecast by a team from the Indian Institute of Science Education and Research in Kolkata has published their prediction for a cycle similar in size or slightly larger than the current one, with a peak in 2024. If correct, it could mean that the previous opinions that the Sun's activity is fading might be reversed.

With still so much to learn about processes that play out over the full surface of the Sun is it clear that we need more data. But one of the limiting factors comes from our viewpoint. All our telescopes take images from close to the plane of the Sun's equator, when many of the important processes take place near the poles. The solution to this predicament is the European Space Agency's Solar Orbiter mission. Due to launch next year, it will become the first spacecraft to take images of the Sun from a high-latitude vantage point. We will be able to track the magnetic field that drives one cycle into the next, filling in the gaps in our knowledge. From this new physical theories will be developed and, we hope, we will finally unlock the secrets of the solar cycle.

The striking wooden design of the Kielder Observatory was the winning entry in a competition organised by astronomer Gary Fildes

Deep sky, DARK FOREST

Elizabeth Pearson explores the extraordinary dark skies found above Kielder Observatory

With every metre I drive through the winding roads of Kielder Water and Forest Park the trees around me seem to grow taller. Despite being just an hour away from Newcastle, I feel like I am in the wilderness, heading ever deeper into the forest.

Then I turn a corner and the tree line stops and the landscape opens out, revealing a large valley. In the distance a lake glistens in the late afternoon Sun and, in front of me, a hillside is covered with Christmas trees. Nestled in the middle of them is a wooden building, seemingly sailing out into the sky. This is Kielder Observatory.

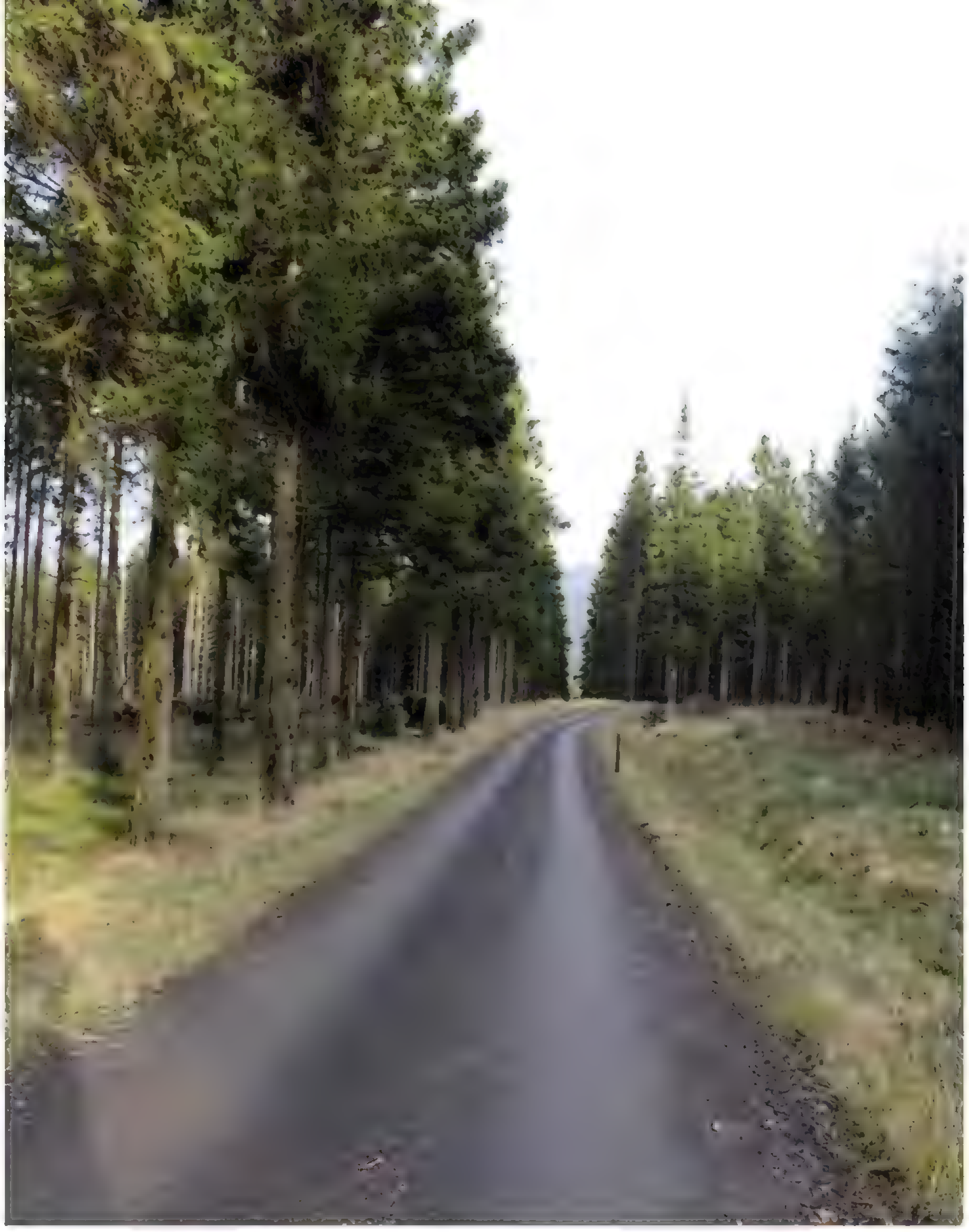
Kielder Forest has long been a place for visitors who appreciate nature and wildlife, but it's also somewhere you can enjoy one of our most overlooked natural resources – the night sky. ▸

GARY FILDES

▸ With the Sun still up we'll have to wait for the headline act. For now, my fellow visitors and I are invited inside to hear about the aurora.

Since opening in 2008, Kielder Observatory has run thousands of similar sessions, talking about all aspects of the cosmos around us – from the Moon, through to distant exoplanets, all the way to the far reaches of the Universe.

"We welcome everyone and try to engage with them on their level," says Becky Cooper, a science presenter at Kielder. "We get a wide range of visitors, from really young kids to senior citizens; people who've never studied space before and those who have. Kielder is accessible to everyone, we don't want to alienate anyone – pardon the pun."



▲ Getting away from it all: the treelined road through Kielder Forest

DAN MONK X 2, ELIZABETH PEARSON X 3

Darkness visible

When our talk is over, we head outside once again and the view around the observatory has completely transformed. The Sun has set, revealing one of the darkest skies I have ever seen, studded with hundreds of stars. Immediately my eyes are drawn to Orion, hanging directly above the observatory. Though I can see the Hunter from my suburban home, out here I can see the constellation is filled with stars that are usually invisible from my back garden. As my eyes adapt to the dark, ever more stars seem to come into view.

While the sky is dotted with lights, the valley below is completely dark, without a single streetlight visible. No distant orange glow stains the horizon.

"One of the reasons we are so rural is to escape light pollution," says Cooper. Kielder Forest is home to

Stargazing steeped in nature

From its opening in 2008, Kielder Observatory is now entering its second decade of operations

Kielder was designed to blend in to its natural surroundings

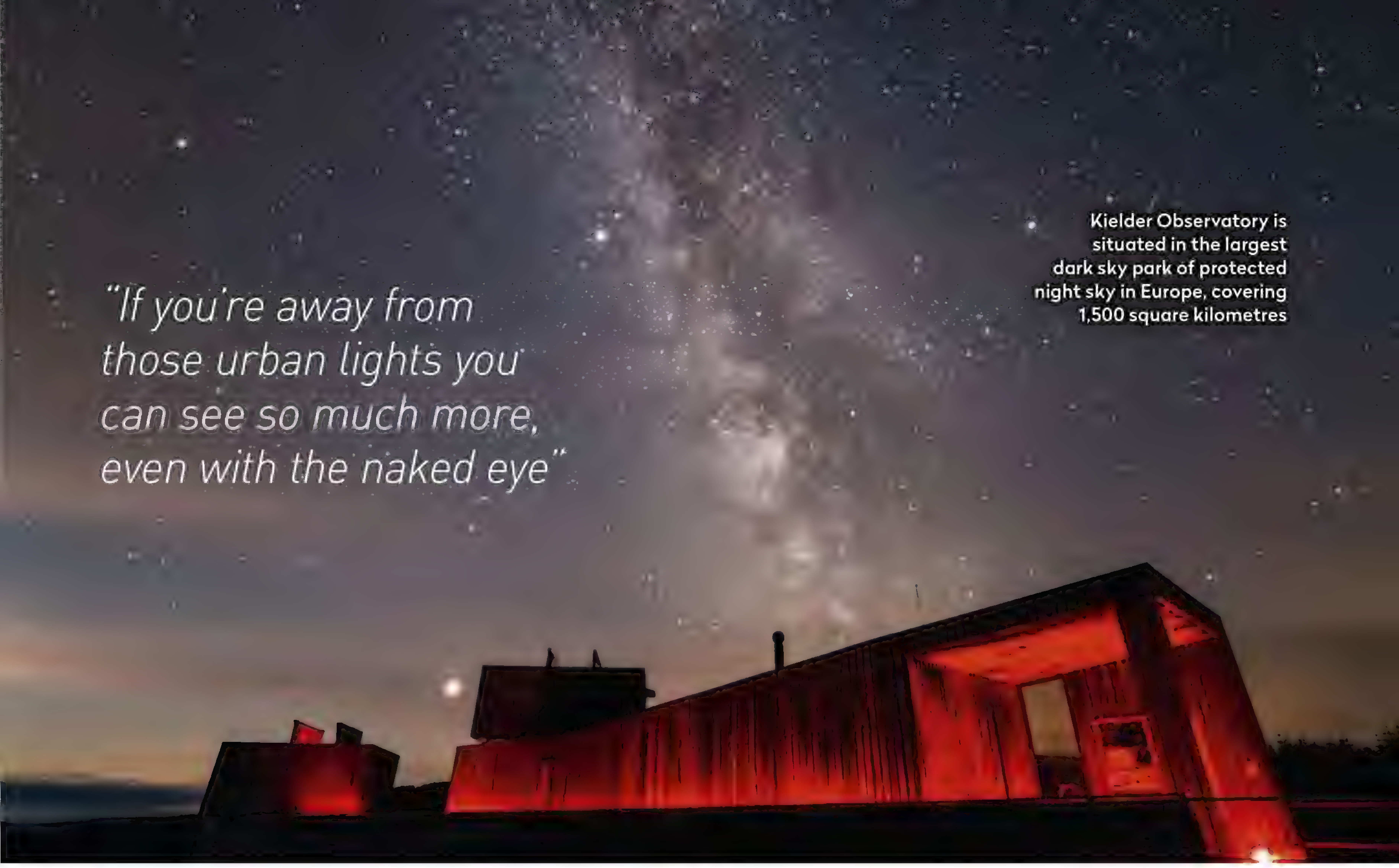
After witnessing the incredible dark skies at Kielder Forest during a star party in the early 2000s, former bricklayer Gary Fildes knew he had to encourage as many people as possible to come and share the wonder.

The long journey towards making the observatory a reality started in 2005, when Fildes ran a competition to design the building. It received over 200 entries. While many of these featured futuristic forms made of glass and metal, the ultimate winner was London-based architect Charles Barclay. When it was finished in 2008, Barclay's wooden creation blended into the surrounding forest and now, 10 years after being built, moss and lichen have softened the edges, making it seem as if the building has always been there.

The main observatory building houses a 'warm room', kept toasty by a wood-burning stove and where 40 people can sit and learn about the Universe around them. There are no windows here; to see the stars you have to wait until it's time to step up into one of the two telescope turrets, the roofs of which open up like a portal to the night sky above.

Both turrets have a full 360°-view of the night sky, and are rotated by hand. The remote location means the observatory is completely off-grid, and the only power is generated by a single wind turbine. While this is enough to run the computers, lights and telescopes, turning two six-tonne roofs would be far too taxing.

Cut off from civilisation, Kielder Observatory is the perfect place to reconnect with the natural world not just around us, but above us too.



"If you're away from those urban lights you can see so much more, even with the naked eye"

Kielder Observatory is situated in the largest dark sky park of protected night sky in Europe, covering 1,500 square kilometres

▲ **Above left: "We're lucky enough to get the Northern Lights," explains Kielder's resident aurora expert Becky Cooper**

Above right: the computer controls that allow visitors a chance to steer a Kielder telescope to a nearby star

the darkest skies in England, and it's Europe's largest accredited dark sky park, covering 1,500 square kilometres of the Northumberland countryside.

"It does make one hell of a difference," says Cooper. "If you're away from those urban lights you can see so much more, even with the naked eye."

Guests don't have to rely on their eyes alone, however, as Kielder is home to a multitude of high-end telescopes. We are invited back inside to one of Kielder's two main turrets, named the Sir Patrick Moore Observatory, which houses a 16-inch Ritchey-Chrétien telescope. It was dedicated to the memory of *The Sky at Night*'s legendary presenter at an unveiling ceremony in 2013.

"We go for a very classic eye-to-eyepiece experience," says Dan Pye, another of the observatory's presenters. "We feel it's the nicest experience."

His point is proved when a younger member of the group is invited to look through the eyepiece, catching her first ever glimpse of the star Sirius.

"It looks like a rainbow!" she says, clearly excited at finding out why Sirius is known as the Rainbow Star.

Afterwards, one of the parents is visibly gleeful as he is allowed to steer the telescope to a nearby star cluster using its computer controls. Unfortunately, the bright Moon prevents us from seeing the best deep sky sights, such as the Milky Way, but the dozens of sparkling stars give us a tantalising hint of what the darkness here can reveal.

Situated just south of the border between England and Scotland, Kielder's northerly location means it is sometimes home to more than just a dark sky.

"We're lucky enough to get the northern lights maybe a handful of times a year," says Cooper, whose ▸

▸ love of the lights has earned her the moniker 'Aurora girl' among the staff.

"It's quite common if you go further north, but it does sometimes stretch this far south. You've got to be quite lucky, but we're always on the lookout because every sighting is special."

On the back wall of the warm room, four screens give a constant update showing the auroral oval and space weather conditions, so that the observatory staff can get all the guests – and themselves – out to see the rare sight, should the lights decide to dance in the sky above.

Unfortunately for us, activity remains stubbornly low. Despite the clear skies, it seems we won't be treated to one of the few times the night sky seems to come alive with colour, even to the naked eye.

Adding colour

As our eyes aren't as good at picking up colour at low-light levels, the generations brought up on incredible Hubble images can sometimes find the dim view through an eyepiece disappointing. "We get asked 'why can't we see colour' a lot," says Pye.

And so last year Kielder Observatory built the Gillian Dickinson Astro-imaging Academy. This second building not only allows the team to take on more guests, but also has space for another two telescopes on piers, this time set up for astroimaging. Housed in a roll-top observatory, where the entire ceiling can be rolled back to give telescopes – and the astronomers using them – a complete view of the sky.

"Now we can say, 'Look, this is what you can see with your eye', and then take a picture of it and show how different it looks," says Pye.

As well as giving a deeper view of the cosmos through imaging, the new building allows them to delve deeper into the practicalities of astronomy.

"We hold astrophotography classes, where we encourage everyone to bring along their own equipment and we help to guide them through the set-up process."

The Kielder facilities are still growing, and there are currently plans to build another new building at the site; a permanent planetarium, with construction due to begin later this year.

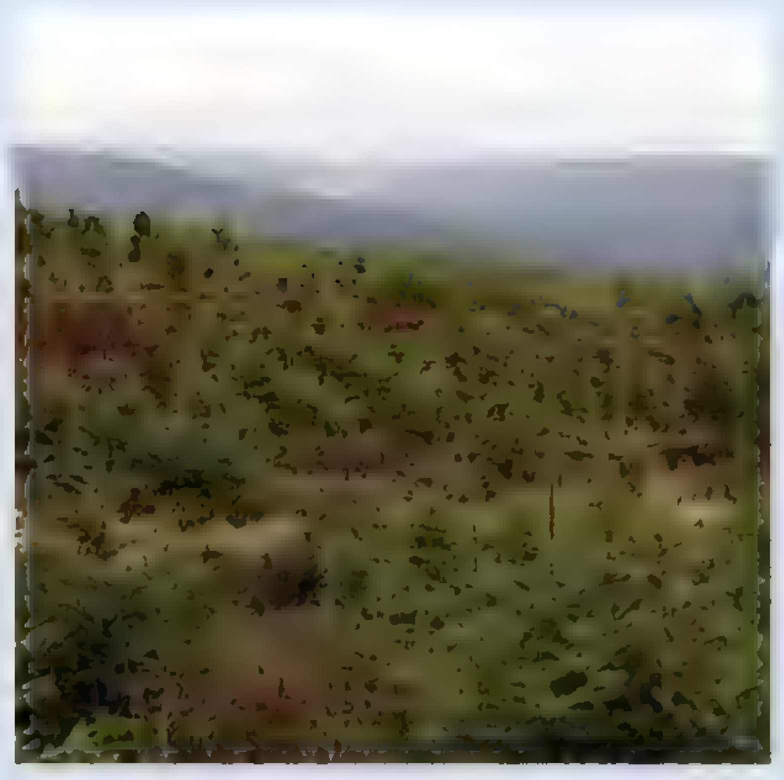
▲ The impressive 16-inch Ritchey-Chrétien scope at Kielder's Sir Patrick Moore Observatory

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

ELIZABETH PEARSON X 2, GARY FILDES, MAP BY PAUL WOOTTON, ISTOCK X 2, TRINITY MIRROR/MIRRORPIX/ALAMY STOCK PHOTO

Things to do by day

There is plenty to entertain the entire family while you wait for darkness to fall

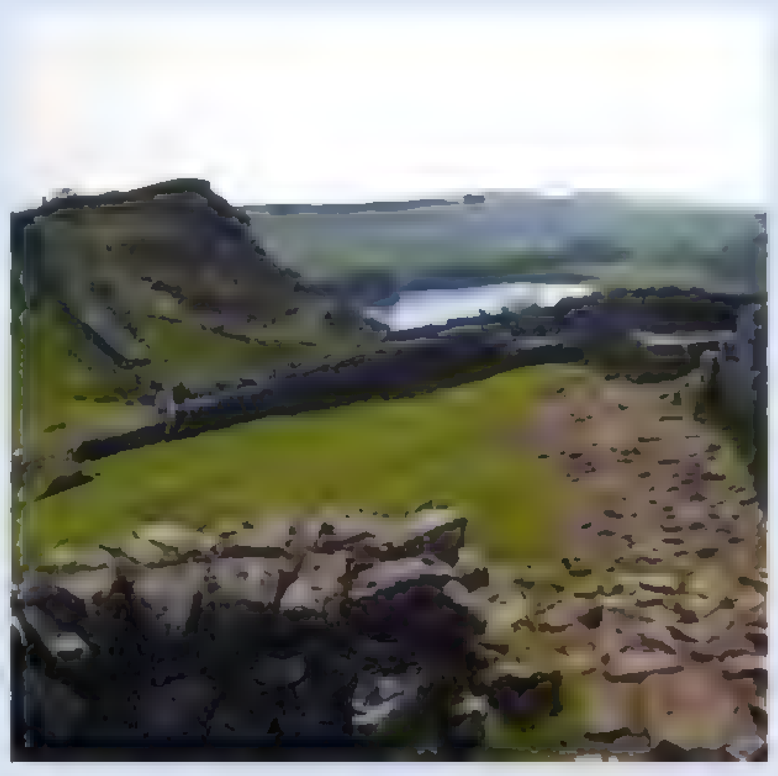


△ Kielder Water and Forest Park

Explore the Park's miles of trails, viewing the many artworks and sculptures, and perhaps even catching sight of a rare red squirrel. In summer canoeing, sailing and water skiing is available on the lake. www.visitkielder.com

▽ Kielder Water Birds of Prey Centre

Home to the largest collection of birds in the north of England, the bird of prey centre aims to promote understanding and conservation of the many wild birds found around the UK. www.kielderbopc.com



△ Hadrian's Wall

The remains of Hadrian's wall, first built in 122AD, lie just a short drive south of the forest. Visit one of the several Roman forts along its length, or hike along the Hadrian's Wall Footpath. Remains of the Wall can also be seen in Newcastle. www.english-heritage.org.uk

▽ Newcastle upon Tyne

The park is just an hour away from the historic city of Newcastle. Explore the city's Roman roots, admire the acclaimed architecture or visit one of the city's many galleries and museums. www.newcastlegateshead.com

◄ Kielder is Europe's largest accredited Dark Sky Park.

Key places to visit are:

1 The Observatory
2 Kielder visitor centre
3 Kielder Water Birds of Prey Centre
4 Tower Knowe visitor centre
5 Housesteads Roman fort and Hadrian's Wall

▲ A stunning view of the Milky Way, extending up from the rooftop of the Kielder Observatory

"It's going to be great for those nights when the weather is a bit ropey – this is England after all, and we do experience cloud," says Pye.

As well as opening up the potential to accommodate day-time visitors, the planetarium will mean the stars are visible even when the weather conditions are overcast. While not the same as a clear, dark sky it will give guests a hint of the experience. Meanwhile, Kielder has already been reaching out to one vital group of people who struggle to get to the observatory in the first place.

"With schools we've found the transport costs can be prohibitive," says Cooper. And so, Kielder decided that rather than bring the kids to the observatory, the observatory would go to them.

"We recently got a big, inflatable planetarium dome – think of a big, blue igloo – that we take to school halls to show them how the night sky would look from there. We've got all these demonstrations with infrared cameras and we take meteorities out to them as well. The kids get really excited because it's different, fun and interactive. Teachers do a great job, but if we can inject a little jazz for the kids that will bring it to life for them," says Cooper.

The Kielder Observatory has funding for the next three years, allowing its presenters to travel to schools throughout the north of England, teaching students all about the wonder of the Universe that surrounds us.

Hopefully, most visitors to Kielder won't have to rely on either planetarium, as nothing can truly match seeing the star-studded darkness above first hand. It's a sight I, for one, will always remember.

For more information about the Kielder Observatory visit: www.kielderobservatory.org

BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

MAY 2019

PETE LAWRENCE

GOOD LIBRATIONS

A favourable libration reveals the Moon's magnificent Humboldt crater

ASTEROID BONANZA

From Ceres to Fortuna, we explore a collection of bright minor planets

SKY GUIDE CHALLENGE

Can you find your way through Virgo by hopping galaxies?

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Don't miss...

- ✦ Eta Aquariid meteor shower peak
- ✦ Ceres at opposition in Ophiuchus
- ✦ Saturn's appearance near dwarf planet Pluto – a photo opportunity

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky, sign up to our newsletter: **www.skyatnightmagazine.com/iframe/newsletter-signup**

MAY HIGHLIGHTS

Your guide to the night sky this month

Wednesday

1 Callisto, Jupiter's outermost Galilean moon, will be positioned to the north of Jupiter's disc this morning.

Thursday

2 Venus and the Moon will remain close throughout the day. At 11:30 BST (10:30 UT), both objects appear due south, approximately one-third of the way up the sky. Venus will be 4.5° north and slightly east of the 6%-lit waning crescent Moon.

Friday ▶

3 Today, it's the turn of Mercury to appear close to a 2%-lit waning crescent Moon in the daylight sky. However, unlike Venus, mag. –0.4 Mercury is not visible to the naked eye in a blue sky. Both objects are a little over 40° up, due south at 12:00 BST (11:00 UT).

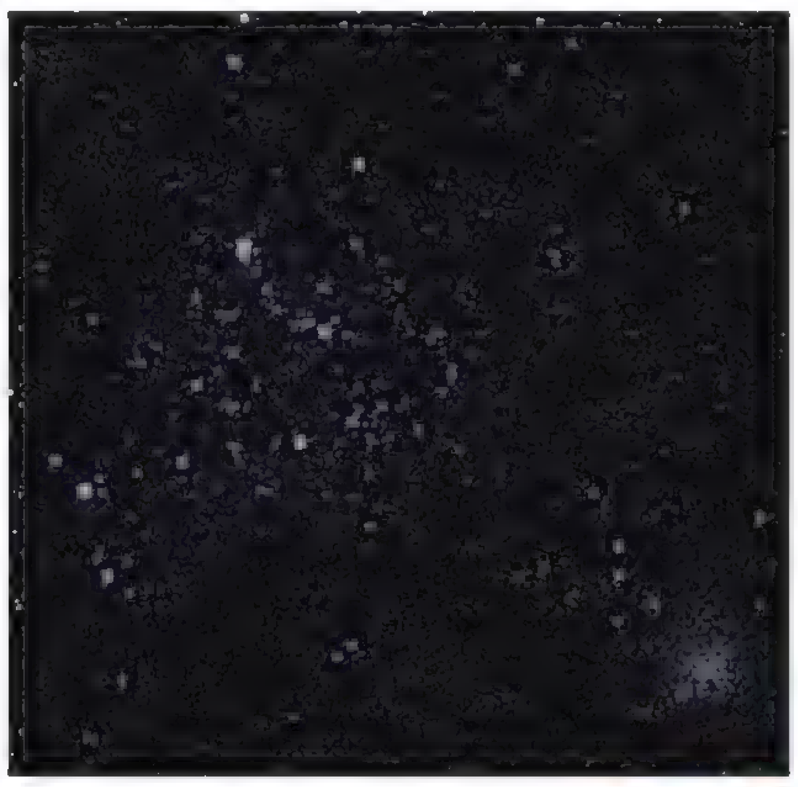
◀ Saturday

11 Minor planet 8 Flora reaches opposition at mag. +9.7 in Libra.

The clair obscur effects known as the Lunar X and V reach peak visibility at 18:45 BST (17:45 UT).

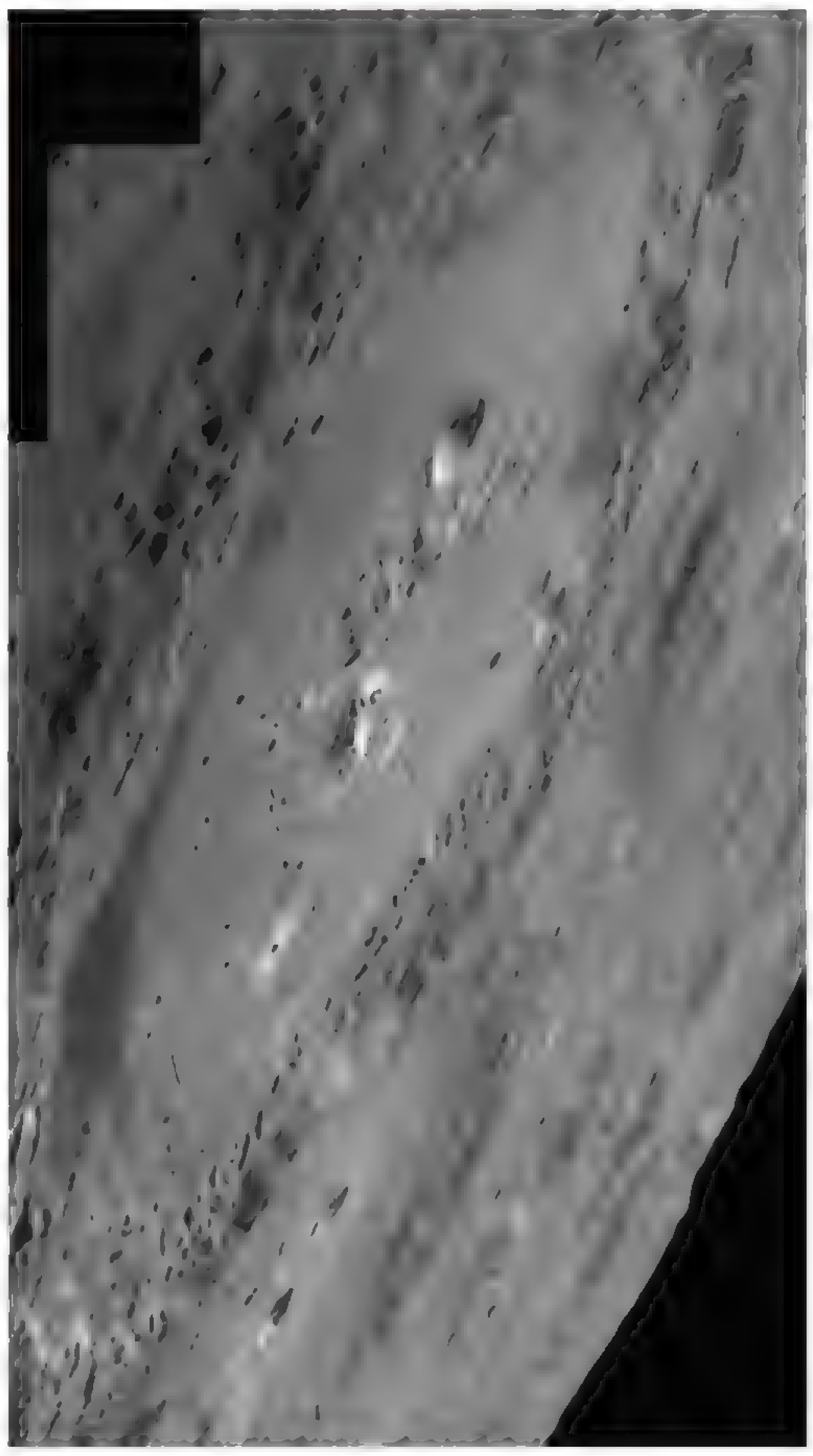
Saturday ▶

18 Tonight and tomorrow night Mars passes very close, clipping even, the open cluster Messier 35. The event is visible low in the evening sky following sunset.



Sunday ▶

19 The Moon's small rocking and rolling action, known as libration, favours the southeast limb. This evening the massive crater Humboldt is well presented close to the terminator, the divide between lunar day and night.



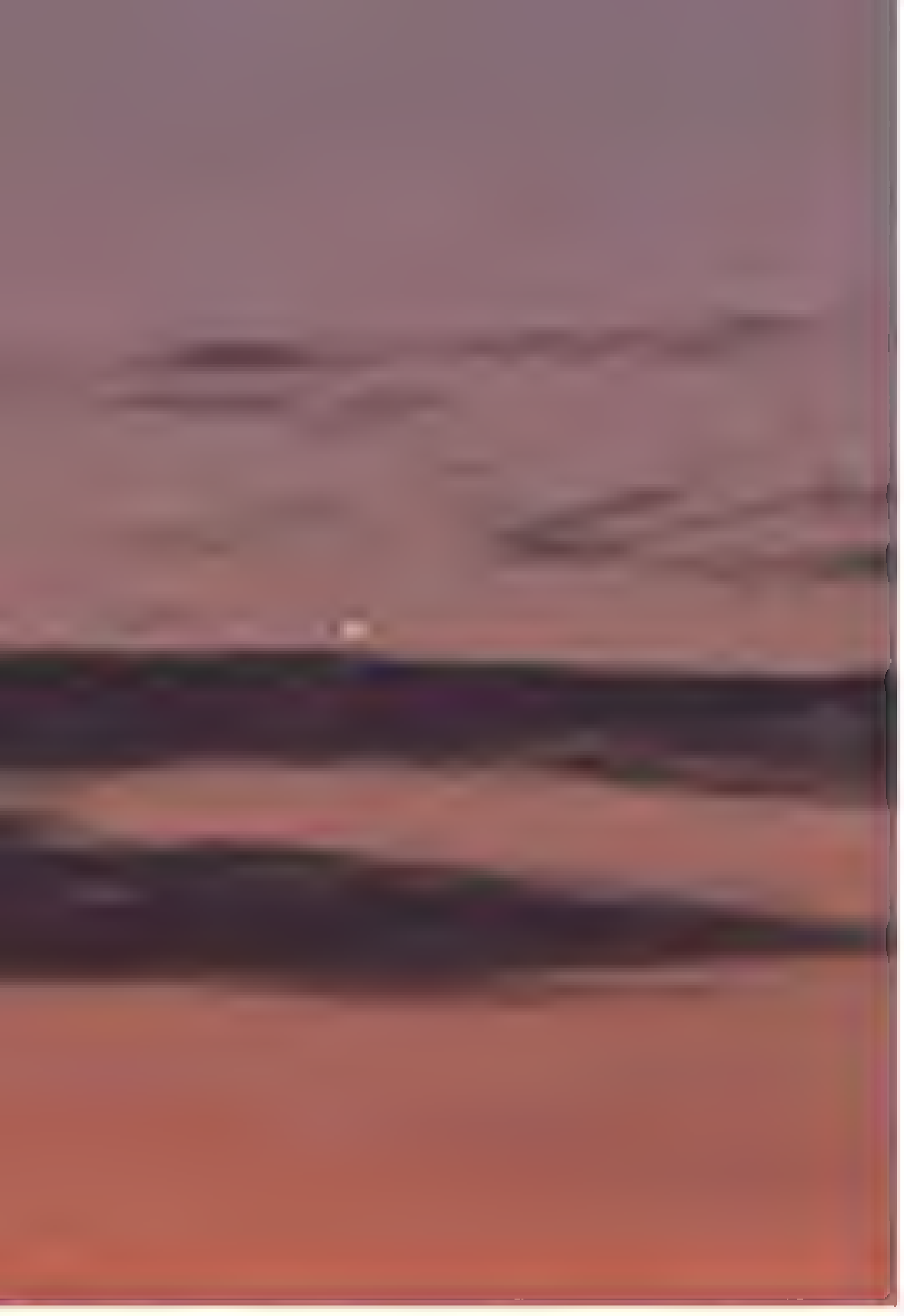
Family stargazing – Star hopping

Star hopping is a great way of navigating the night sky to learn at a young age. Look overhead as the sky darkens and try to find the Saucepan. The sides of the pan point down towards the bright star Regulus in Leo – easily identified because of the backward question mark of stars rising above it. Return to the Saucepan and extend the line of the two stars in the pan furthest from the handle in the opposite direction to Regulus to arrive at Polaris, the North Star. Finally, extend the curve of the Saucepan's handle away from the pan to arrive at bright orange Arcturus. Keep going along the arc and you'll arrive at white Spica.

Thursday

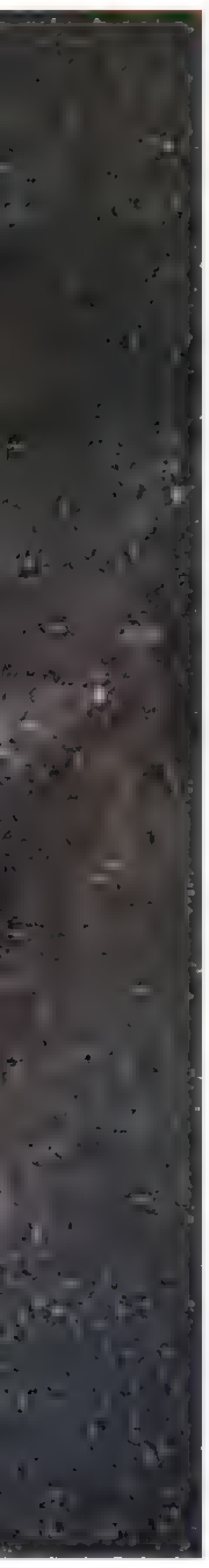
23 This morning's 82%-lit waning gibbous Moon sits 1.9° southeast of mag. +0.7 Saturn as it rises above the southeast horizon just after 01:00 BST (00:00 UT).

PETE LAWRENCE X 8



Saturday 4
Saturn is currently 2.7° west of Pluto in the morning sky.

Sunday 5
Tonight sees the peak of the Eta Aquariid meteor shower. Conditions this year are favourable as the Moon will be out of the way. The shower has a peak Zenithal Hourly Rate (ZHR) of 28 meteors per hour, but favours the southern hemisphere.



◀ Monday 6
With the Moon out of the way, why not try this month's Deep Sky Tour (see page 56) which looks at objects close to Scorpio's heart?

Tuesday 7
Mag. +1.7 Mars is currently positioned between the Bull's horn tips of Taurus. This evening it is joined by a 9%-lit waxing crescent Moon 4.5° to the south-southwest.

Friday 10
Tonight is the maximum hourly rate of the weak Eta Lyrid meteor shower, which has a peak ZHR of 3 meteors per hour.

Our Moonwatch target, the crater Dionysius, is revealed tonight (see page 52).

Tuesday 14
The minor planet 11 Parthenope reaches opposition at mag. +9.5 in Libra.

Thursday 16 ▶
This evening represents an opportunity to see the clair obscur effect known as Cassini's Moon Maiden. The maiden is part of Promontorium Heraclides, marking the southern end of Sinus Iridum and best seen with south up.

Monday 20
Minor planet 20 Massalia reaches opposition at mag. +9.7 in Libra (page 53).

As the Moon rises above the southeast horizon, after 23:00 BST, mag. –2.4 Jupiter is 3.3° to the west of it.

Tuesday 28
Dwarf planet 1 Ceres reaches opposition at mag. +7.0 in Ophiuchus.

Ganymede and its shadow will be in transit as Jupiter rises.

Tuesday 21
We have now reached the approximate start of noctilucent cloud (NLC) spotting season.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

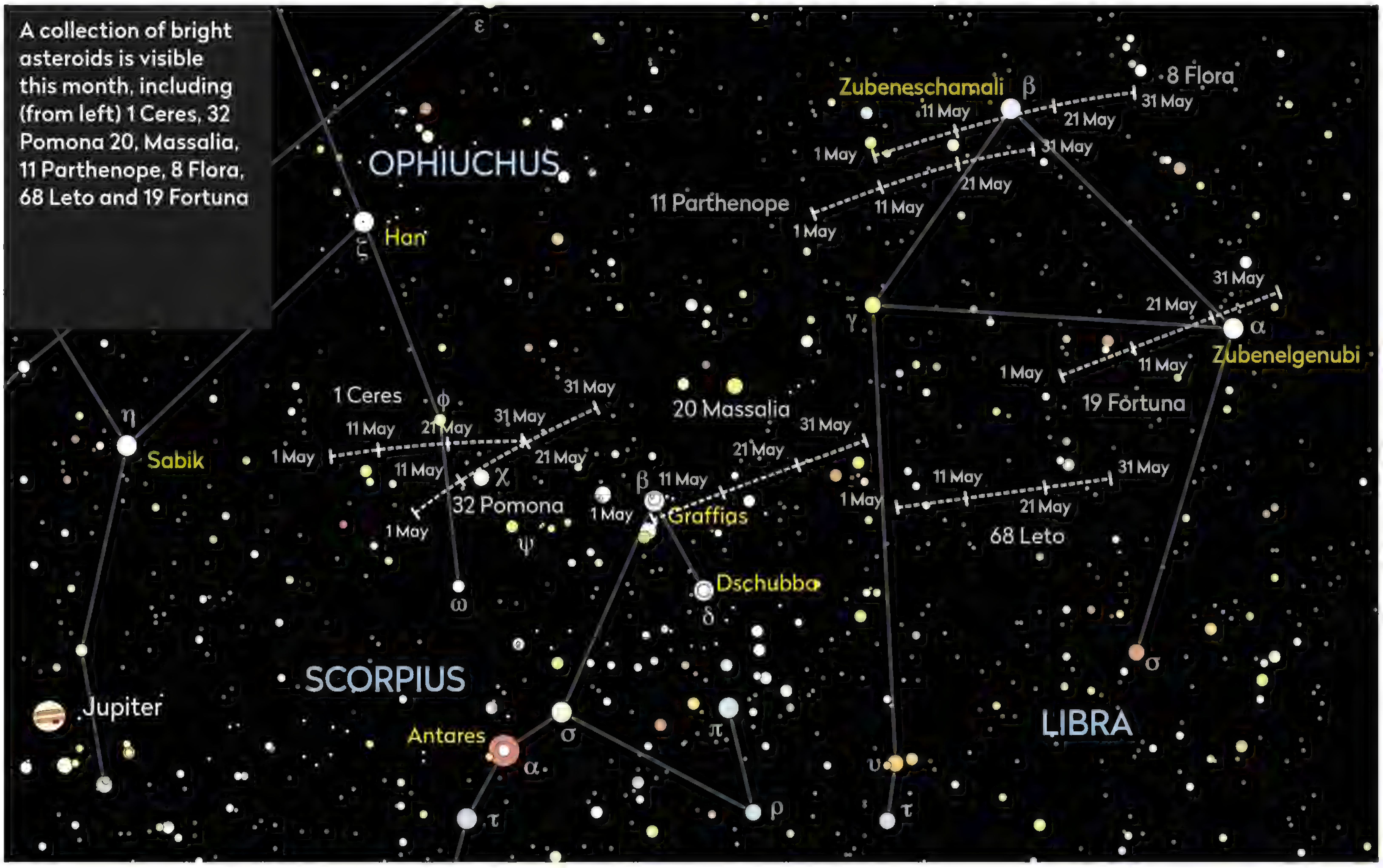
Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY
If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_Lessons** for our 10-step guide to getting started and **http://bit.ly/First_Tel** for advice on choosing a scope.

THE BIG THREE The three top sights to observe or image this month



DON'T MISS

Asteroids GALORE

BEST TIME TO SEE: All month with darkest skies 1-10 May

There are hundreds of thousands of asteroids in orbit around the Sun. Most are small but there are some big ones out there too. The largest, Ceres, was snatched from the asteroid belt in 2006 when it was reclassified as a new type of object known as a dwarf planet. Ceres has a diameter of 946km and was historically the first asteroid discovered. This month it comes to opposition in Ophiuchus, appearing not too far from the planet Jupiter as it does so.

Ceres begins the month at mag. +7.6 and brightens to reach mag. +7.0 at opposition on 28 May. It then remains at this brightness until the end of the month. This makes it an easy target for a small telescope or binoculars and photographing its progress throughout May is a relatively straightforward task.

As well as Ceres there are a number of other relatively bright minor planets reaching opposition this month. Asteroid 8 Flora reaches opposition in Libra. Its magnitude variation throughout the month is from +9.9 on 1 May through to +9.7 at opposition on 11 May and +10.0 on 31 May. Not too far away is 11 Parthenope which starts the month at mag. +9.8, reaches +9.5 at opposition on 14 May and dims back to +9.8 by the end of May. Like Flora, Parthenope is located in Libra this month.

▲ **The dwarf planet Ceres becomes brighter throughout May, reaching opposition on 28 May at mag. +7.0**

Then there's 20 Massalia which moves out of Scorpius and into Libra. This starts May at mag. +10.2, brightens to +9.7 at opposition on 20 May and dims back to +10.1 by 31 May. You can discover more about 20 Massalia on page 53.

This is a good collection of relatively bright asteroids. By using a 35mm or shorter lens on a non-full frame camera or a 55mm or shorter lens on a full frame model, it will be possible to cover the entire star field where these bodies will be moving. If you can catch a number of shots of them throughout the month, and combine them to show how Ceres, Flora, Parthenope and Massalia have moved, this should produce a very interesting result.

Although this is a good collection, it's not the end of the story because in addition to the four listed, there are others in this region which are bright enough for a small telescope or wide field camera to record easily too. Of note are 19 Fortuna which reaches mag. +10.7 on 9 May, 32 Pomona which reaches mag. +10.5 on 23 May and 68 Leto which reaches mag. +10.6 on 15 May. Given clear skies this Solar System gathering will be quite something to record.

A favourable Eta Aquariid meteor shower

BEST TIME TO SEE: 01:30-3.30 BST (00:30-02:30 UT), 6 May

Most meteor showers are associated with comets although there are a few which have asteroids as their parent bodies. Examples include the Quadrantids, Kappa Cygnids and Geminids. The Eta Aquariid meteor shower has a very famous parentage. This is one of two annual showers associated with comet P1/Halley, the first comet recognised to have a periodic orbit.

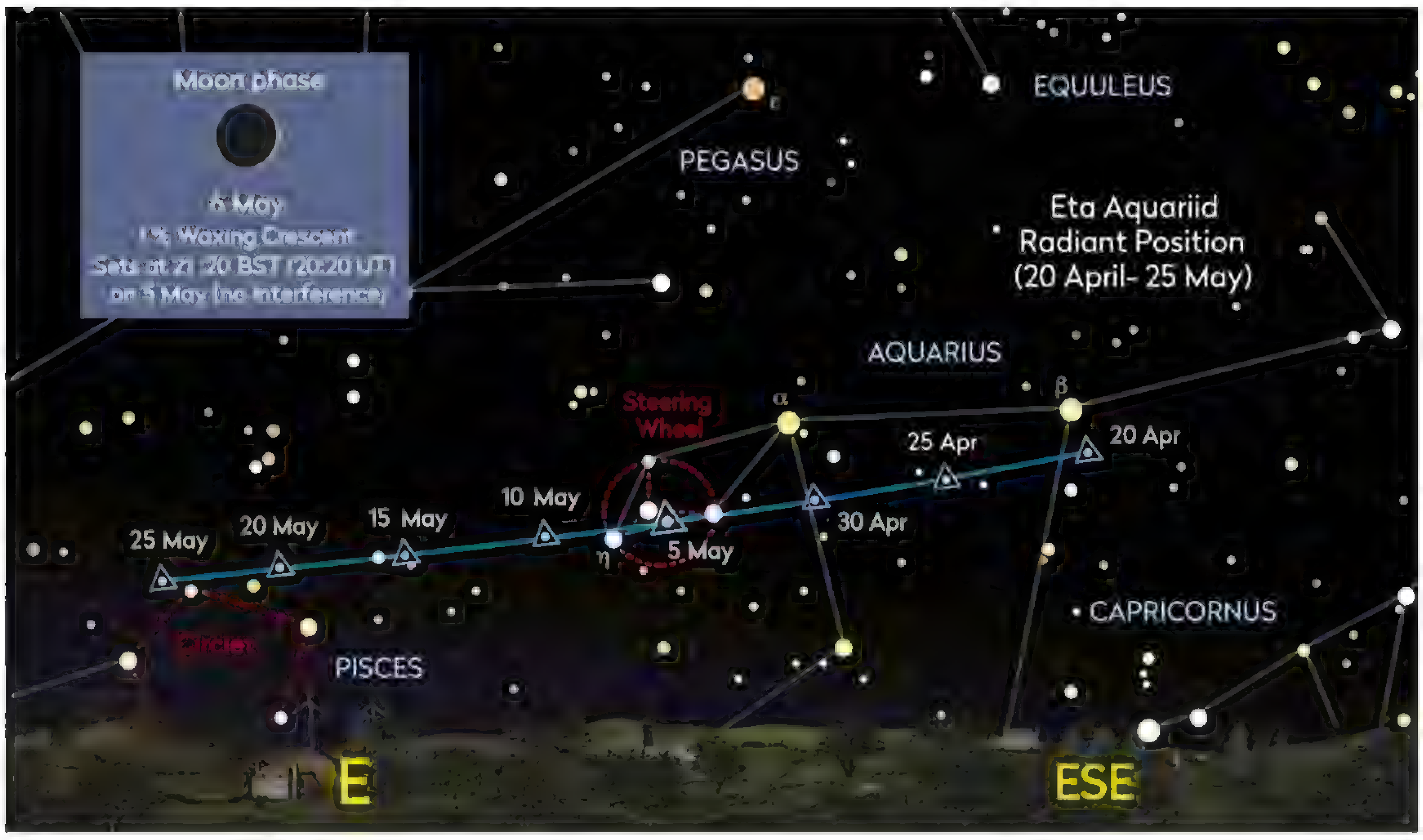
Between 19 April and 28 May, Earth passes through the dust stream strewn around Halley's orbit. The density of the stream reaches its maximum value on the night of 5/6 May and this marks the peak of the Eta Aquariid shower. At peak, activity rises to a ZHR (zenithal hourly rate) of 40 meteors per hour but there are caveats which need to be considered.

The radiant position, the point at which the shower appears to originate to a terrestrial observer, is close to the asterism known as the Water Jar or, in popular culture, as the Steering Wheel. At this time of year this part of the sky only just rises as the dawn's light starts to kick in.

Consequently, the viewing window for the Eta Aquariids shower is quite short, say from 01:30-03:30 BST (00:30-02:30 UT) on 6 May.

As the radiant position is low – actually below the horizon at 01:30 BST (00:30 UT) – there will be a substantial difference between the ZHR figure and the number of meteors you're actually likely to see.

On the plus side, the Moon is out of the way, being new on 4 May. So despite a low visual rate, at least the sky will be good and dark in the run up to dawn. As ever, the best advice to see them is to find a dark spot away from stray lights. Give your eyes at least 20 minutes in darkness to adjust properly, and view the shower at a height of two-thirds up the sky, in any direction.



▲ With minimal Moon interference, early risers will be rewarded with the best views of the Eta Aquariid meteor shower at its peak activity, from 01:30-03.30 BST on 6 May

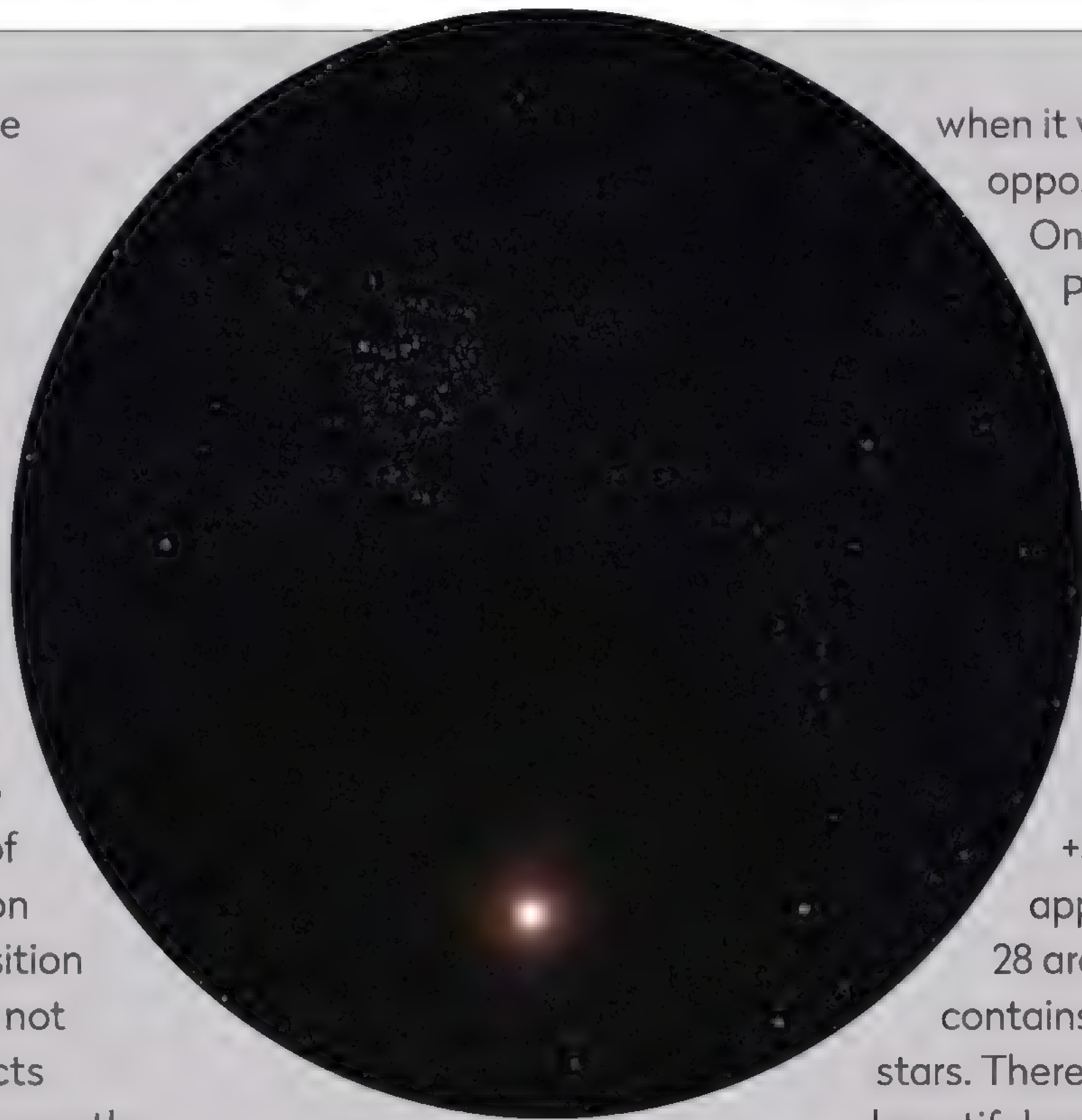
Mars and M35

BEST TIME TO SEE: 18-19 May as the sky darkens

At the start of April, Mars passed south of the Pleiades open cluster, M45, a lovely sight if you had clear skies. This month, the Red Planet will have another apparent encounter with a cluster, the lovely M35 in Gemini. Although this cluster can be glimpsed with the naked eye under dark sky conditions, it lacks the brilliance of the Pleiades. Consequently, you'll need binoculars or a low power telescope to get the best views.

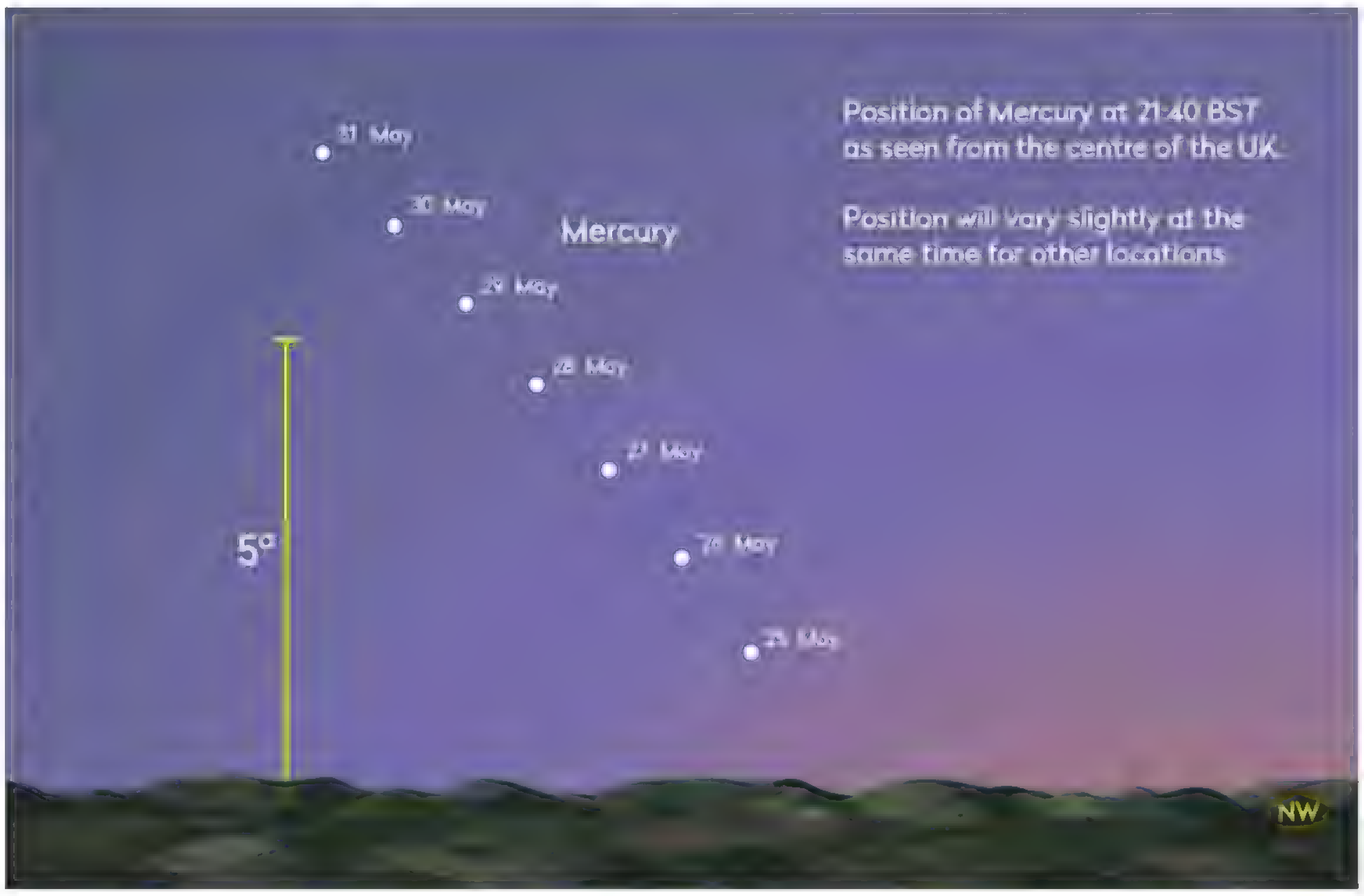
Unlike the Pleiades pass, which saw Mars approach within 3.5° of M45, the encounter with M35 has Mars passing over the northern reaches of the cluster. The conjunction can be seen on the night of 18 May and again on 19 May, but the position of Mars and M35 is not optimal, both objects appearing rather low as the sky darkens.

Mars will be at mag. +1.7 on 18 May, much dimmer than when it was last at opposition on 27 July. On that date the Red Planet shone at mag. -2.8 which was brighter than Jupiter. Despite this, it will still outshine the cluster which has an integrated magnitude of +5.5. M35 has an apparent diameter of 28 arcminutes and contains several hundred stars. There are some beautiful red-hued stars here too, which should provide an interesting comparison with Mars.



▲ A previous encounter between the Red Planet and star cluster M35 in October 2007

THE PLANETS Our celestial neighbourhood in May



▲ From 25–31 May, Mercury will be visible for longer periods after sunset, from 35–70 minutes

PICK OF THE MONTH

Mercury

Best time to see:
31 May, 30 minutes after sunset
Altitude: 4° (very low)
Location: Taurus
Direction: Northwest
Features: mottled surface, phase changes
Recommended equipment: telescope, with 6-inch aperture or larger

PETE LAWRENCE X 3

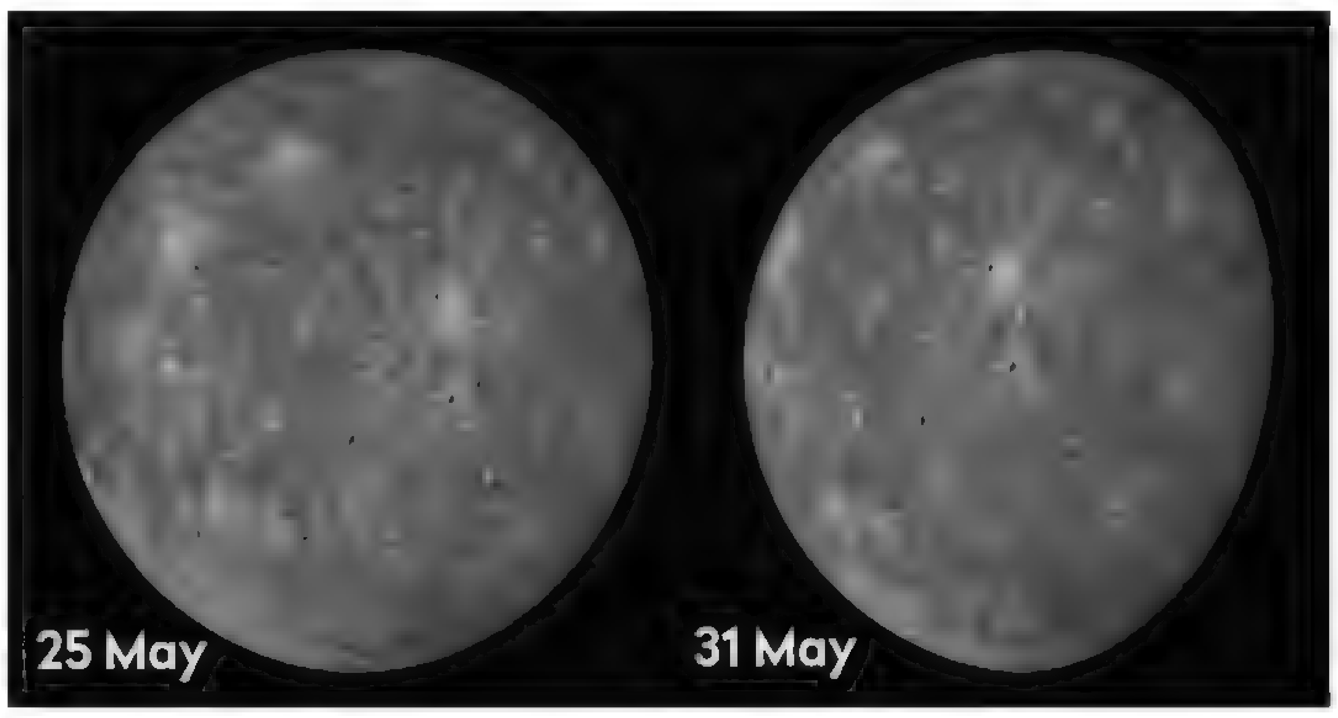
To be honest, Mercury is quite poorly positioned for most of the month. On 1 May it is located in the morning sky, rising barely 20 minutes before the Sun. It's best located by the presence of its outer Solar System neighbour, Venus, located 7.5° to the west. Despite this, the low dawn altitude of mag. –0.3 Mercury is probably going to keep it hidden from view.

Things don't improve much over the following days either, the planet gradually creeping closer to the Sun and remaining very low just before sunrise. The only saving grace is that its brightness is increasing. On 12 May it shines at mag. –1.0 but only reaches a height of 1° before sunrise.

Solar conjunction occurs on 21 May when Mercury lines up with the Sun on the far part of its orbit relative to Earth – a superior conjunction. You might think that this doesn't give Mercury much time to redeem itself in what remains of May, but you'd be wrong. In the following days Mercury pulls further to the east of the Sun and is visible in the evening sky as a consequence.

By 25 May, Mercury will have pulled far enough from the Sun to set 35 minutes after sunset. It will be shining at mag. –1.7, with good prospects for spotting if there's a flat northwest horizon and clear skies.

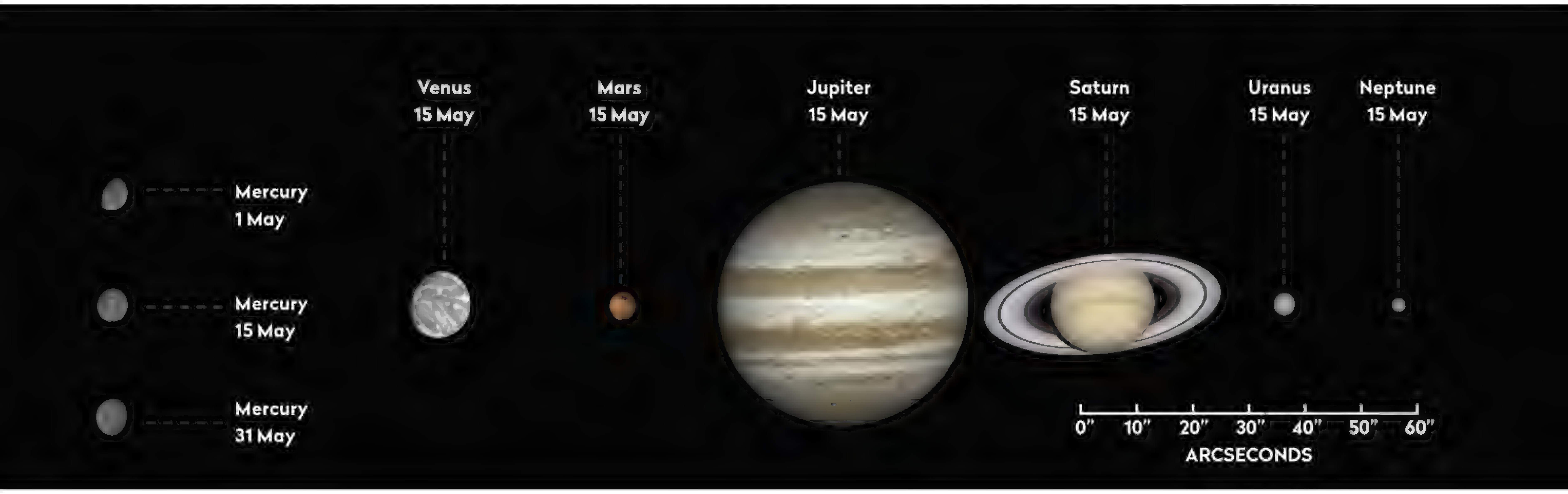
On following evenings Mercury will increase its apparent distance from the Sun. This will be countered by the planet dimming. By 31 May, Mercury will shine at mag. –1.1, setting 70 minutes after sunset. Being on a far section of its orbit, a telescopic view will show it as a tiny 5 arcsecond disc, almost fully lit on the 25 May at 97% illumination, dropping to 87% on 31 May.

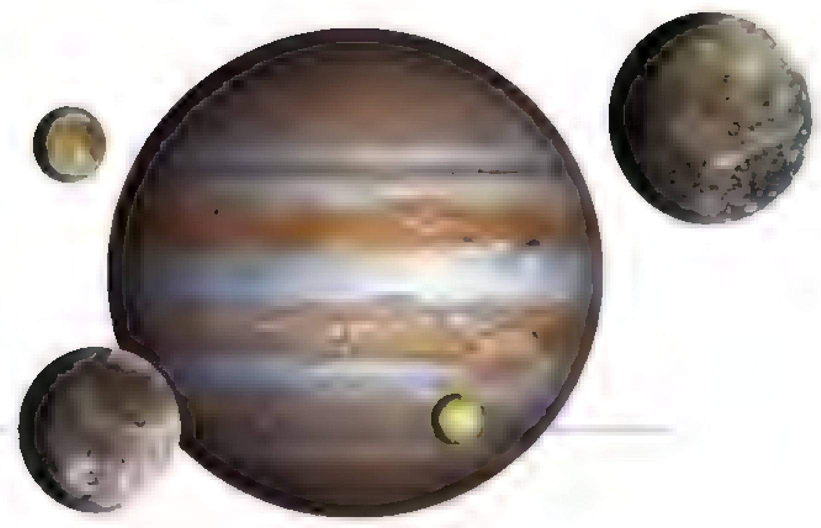


▲ Mercury's phase changes from 97% to 87% from 25 to 31 May

The planets in May

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Venus

Best time to see: 31 May, 30 minutes before sunrise
Altitude: 1° (extremely low)
Location: Aries
Direction: East-northeast

On 1 May, in the pre-sunrise sky, Mag. –3.8 Venus, Mag. –0.3 Mercury and a 7%-lit waning crescent Moon all appear close to one another. However, their altitude is low at sunrise so don't expect them to be easy targets. On 1 May, through a telescope Venus appears 88%-lit and 11 arcseconds across, figures which adjust to 93%-lit and 10 arcseconds by the month's end. This is caused by Venus moving along a part of its orbit which is furthest from Earth. The planet isn't particularly well placed at the start of May, rising 30 minutes before the Sun, but this improves slightly by the end of the month, with Venus rising 45 minutes before the Sun. This is despite the fact that Venus's apparent separation from the Sun is decreasing.

A slim 7%-lit waning crescent Moon hangs below and right of Venus on the morning of 2 May. Look for the pair low above the eastern horizon before sunrise.

Mars

Best time to see: 1 May, 22.30 BST (21:30 UT)
Altitude: 14°
Location: Taurus
Direction: west-northwest

We're quickly losing Mars as its altitude drops rapidly following sunset. Telescopically the planet now appears too small for serious observation, showing a disc which is around 3 arcseconds across. There's an attractive arrangement of the planet and a 9%-lit waxing crescent Moon on the evening of 7 May. Look for this from around 23:00 BST (22:00 UT). Although it's getting very low in the evening twilight by 18 May, if you can spot mag. +1.7 Mars low in the northwest that evening it'll be approaching the open cluster M35 in Gemini. It appears against the northeast edge of the cluster on 19 May.

Jupiter

Best time to see: 31 May, 02:00 BST (01:00 UT)
Altitude: 14.5°
Location: Ophiuchus
Direction: South

Jupiter is a low but bright, mag. –2.4 object located in the southern part of Ophiuchus at present. It's close to the lowest part of the ecliptic seen from the UK. Not surprisingly, it only attains a peak altitude of around 15° when due south as seen from central UK. A bright 94%-lit waning gibbous Moon lies 3.7° to the east of Jupiter on the morning of 20 May.

Saturn

Best time to see: 31 May, 02:45 BST (01:45 UT)
Altitude: 13°
Location: Sagittarius
Direction: South-southeast

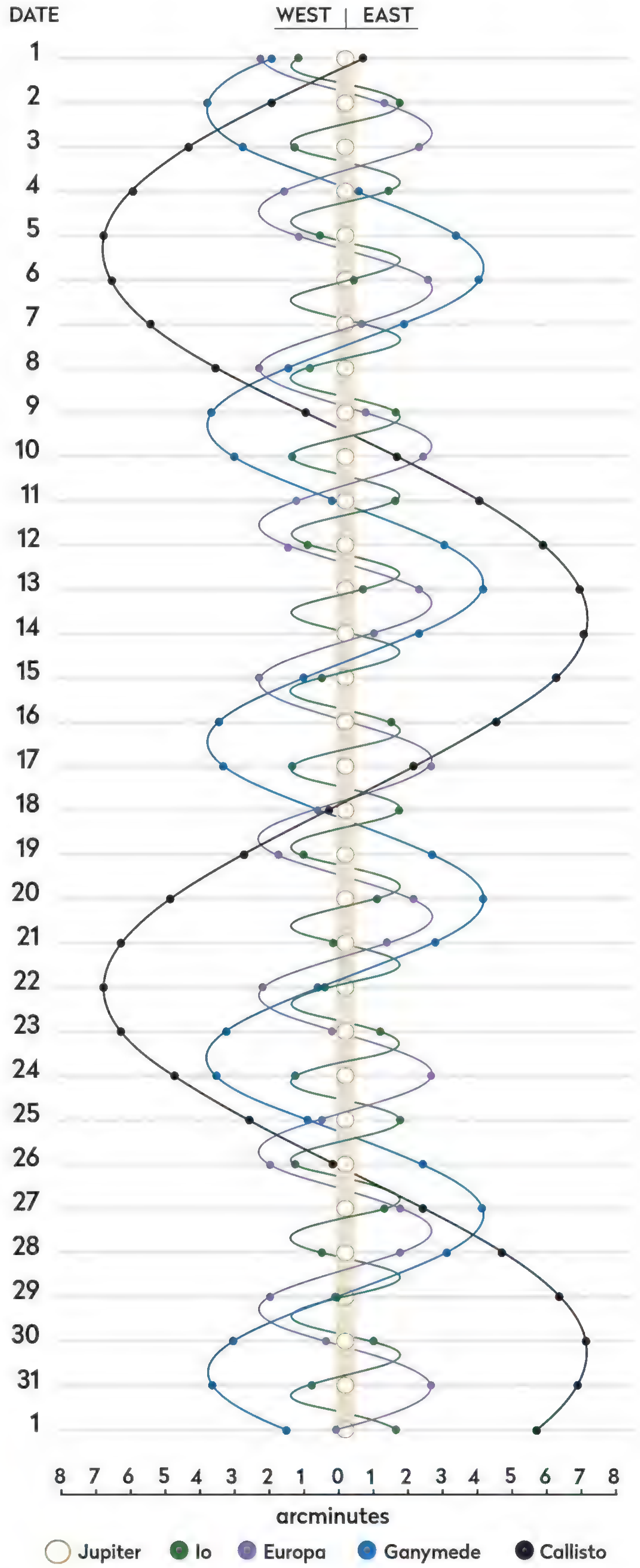
Saturn is a morning object, battling the shorter nights to attain a reasonable altitude before morning twilight gets too bright. It's currently located in the constellation of Sagittarius, south of the Teaspoon asterism. Shining at mag. +0.8, Saturn is close to dwarf planet Pluto. Although Pluto is dim at mag. +14.3, it would be interesting to try and photograph both together. A bright 82%-lit waning gibbous Moon sits 2.1° to the southeast of Saturn on the morning of 23 May. If you look at Saturn through a scope, its northern pole is tilted towards Earth by around 23.6°.

Not visible this month
Uranus, Neptune

More ONLINE
Print out observing forms for recording planetary events

JUPITER'S MOONS: MAY

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – MAY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

CHART: PETE LAWRENCE

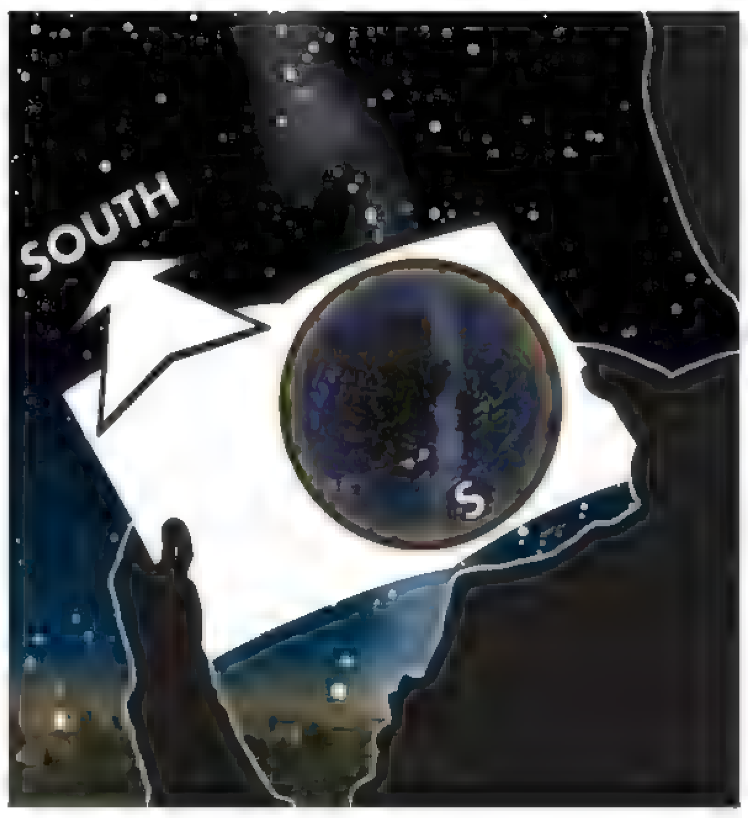
When to use this chart

1 May at 01:00 BST
15 May at 00:00 BST
31 May at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in May*

Date	Sunrise	Sunset
1 May 2019	05:36 BST	20:39 BST
11 May 2019	05:17 BST	20:57 BST
21 May 2019	05:01 BST	21:13 BST
31 May 2019	04:49 BST	21:27 BST

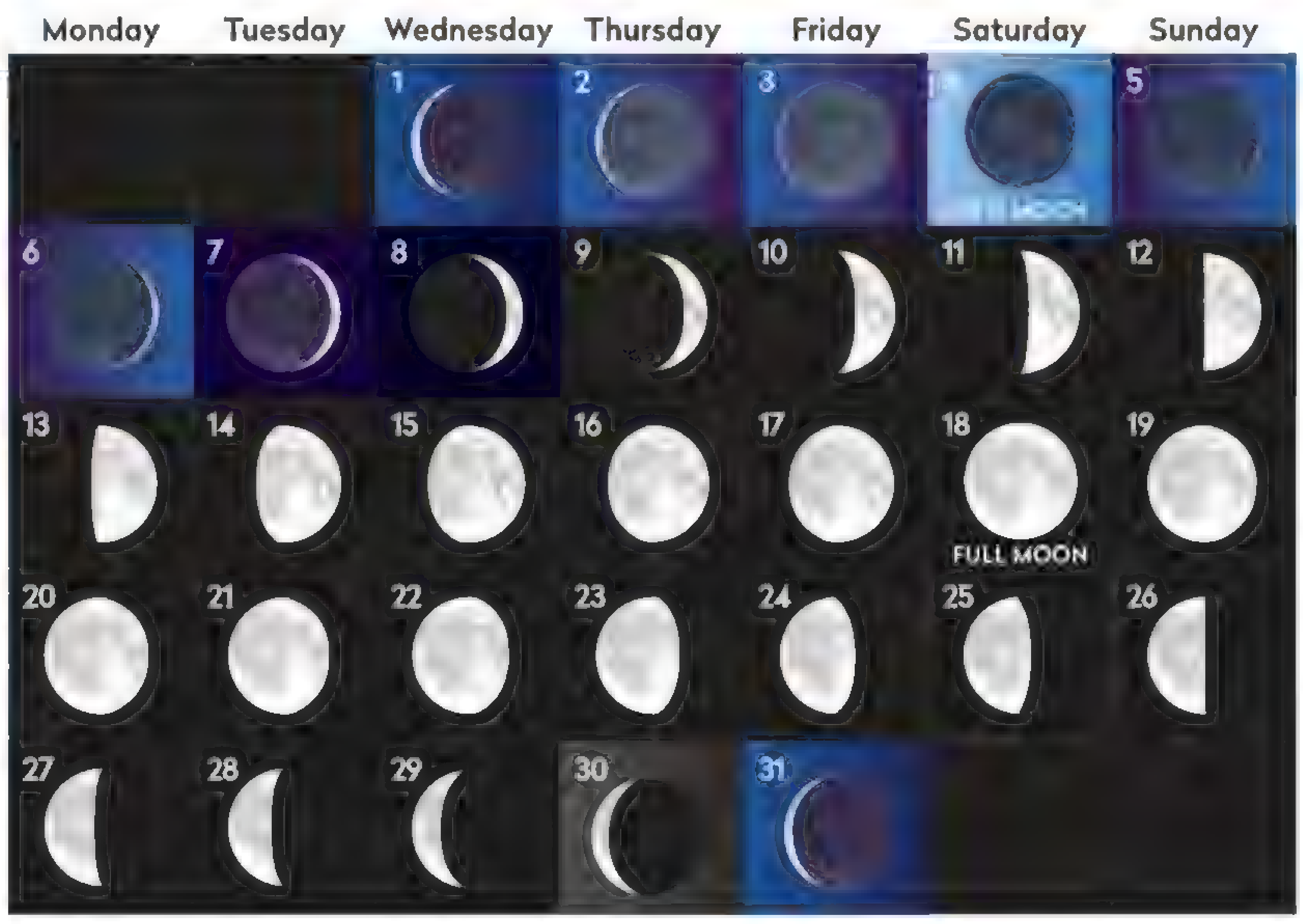
Moonrise in May*

Moonrise times

1 May 2019, 05:01 BST	17 May 2019, 19:16 BST
5 May 2019, 06:14 BST	21 May 2019, 00:03 BST
9 May 2019, 08:46 BST	25 May 2019, 02:03 BST
13 May 2019, 13:48 BST	29 May 2019, 03:24 BST

*Times correct for the centre of the UK

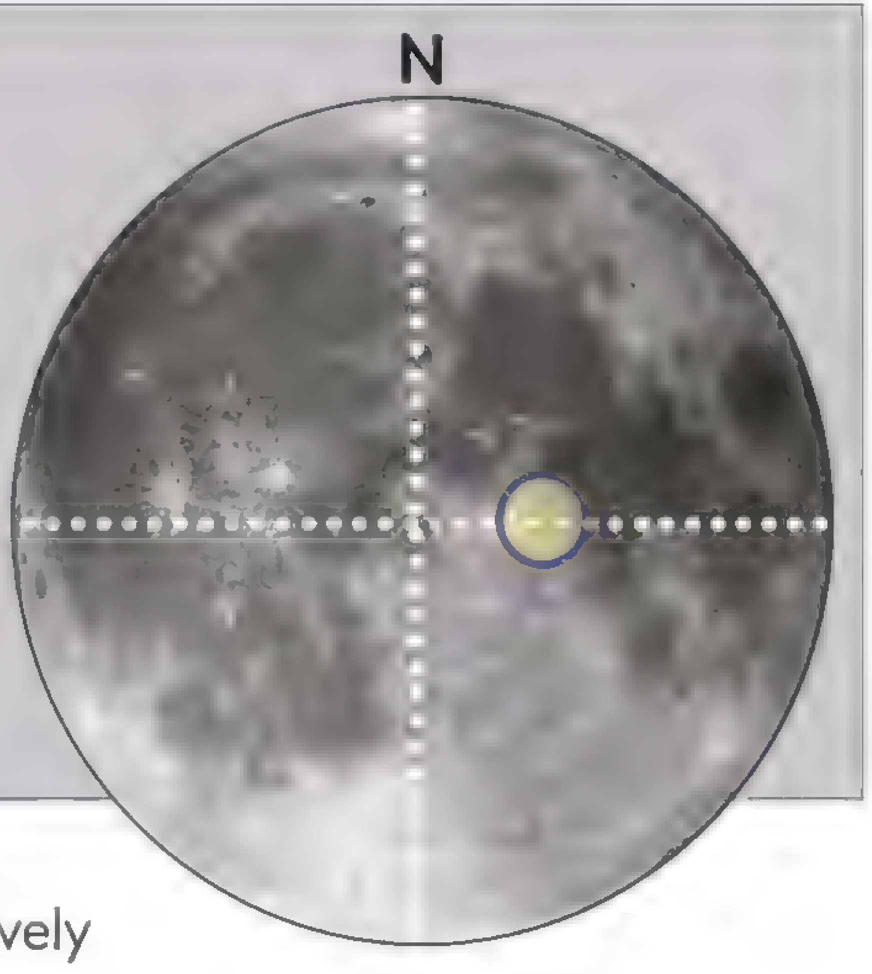
Lunar phases in May



More ONLINE
Paul and Pete's Virtual Planetarium

Dionysius

Type: Crater
Diameter: 18km
Longitude/latitude: 17.3° E, 2.8° N
Age: Younger than 1.1 billion years
Best time to see: Six days after new Moon (10–11 May) and five days after full Moon (24–25 May)
Minimum equipment: 100mm refractor



At 18km in diameter, **Dionysius** is a relatively small crater situated on the western shore of Mare Tranquillitatis. Its largest neighbours are 53km Delambre, 144km to the south (centre-to-centre) and 91km Julius Caesar 203km to the north-northwest. The local region is dominated by the strikingly similar pairing of 31km Ritter and 30km Sabine to the southeast.

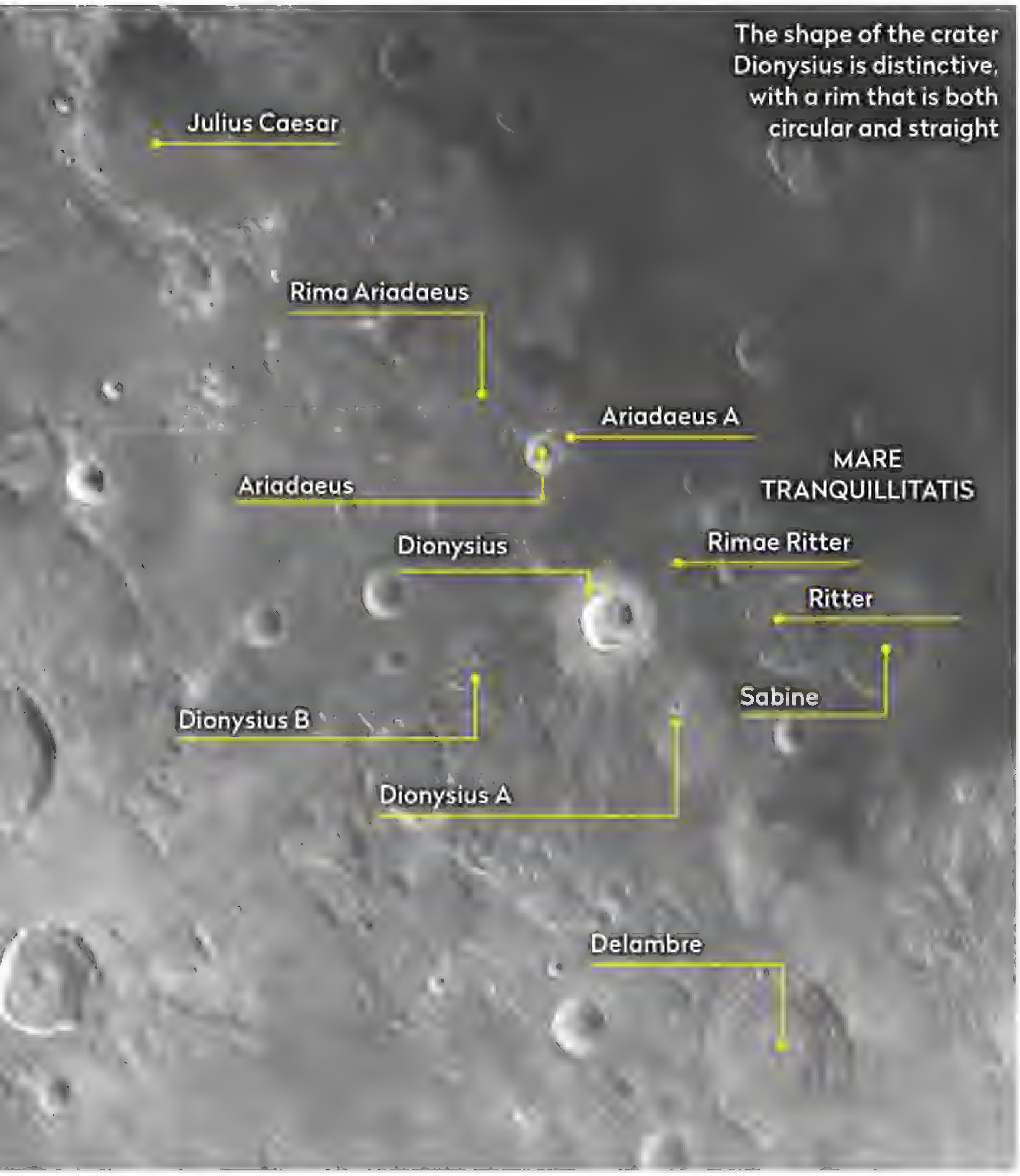
Dionysius has a distinctive shape. The rim running from the northeast, through north and round to the southwest appears as a circular arc. However, the rim sections to the south, southeast and most strikingly to the east are straight. The crater has no central mountain complex, but its rim is clearly raised above the level of nearby **Mare Tranquillitatis**.

This is a young crater and sections of its interior appear quite bright. In addition, the outer surrounds are characterised by young ejecta released from the area when the impact occurred that created Dionysius. The streaks of ejecta form a fine spread of radial rays spreading out from Dionysius. These are evident to the northeast, east and southeast, where they cross the darker lava of Mare Tranquillitatis. With care the rays can be traced for distances over 100km.

The young age of the crater means that much of the material here appears quite bright under high illumination. This is definitely the best time to look for the rays and to experience the brilliance of the crater's interior. Interestingly, careful examination of the ray system shows a number of dark rays. These are relatively rare features forged when dark material was ejected during the crater's formation.

Careful examination shows a number of dark rays, rare features forged during the crater's formation

PETE LAWRENCE X 3



The shape of the crater Dionysius is distinctive, with a rim that is both circular and straight

The region immediately east of Dionysius is interesting to examine under oblique lighting such as that which occurs when the terminator is nearby. Here you should be able to make out up to four sections of a graben. A graben is a rille or groove formed when the surface drops between two parallel fault lines. Known as **Rimae Ritter**, these extend for a total length of 100km and have a width around 3km.

Tracing the graben which forms Rimae Ritter back towards the north will bring you to the 12km crater **Ariadaeus**. This crater appears squashed against 8km Ariadaeus A and it's this crater which appears to stand in the way of the rille. To the north of it the graben can be seen quite clearly once again, swinging around to run west-northwest in the form of the impressive Rima Ariadaeus. This is far better defined than Rimae Ritter and runs for 220km with a width around 7km.

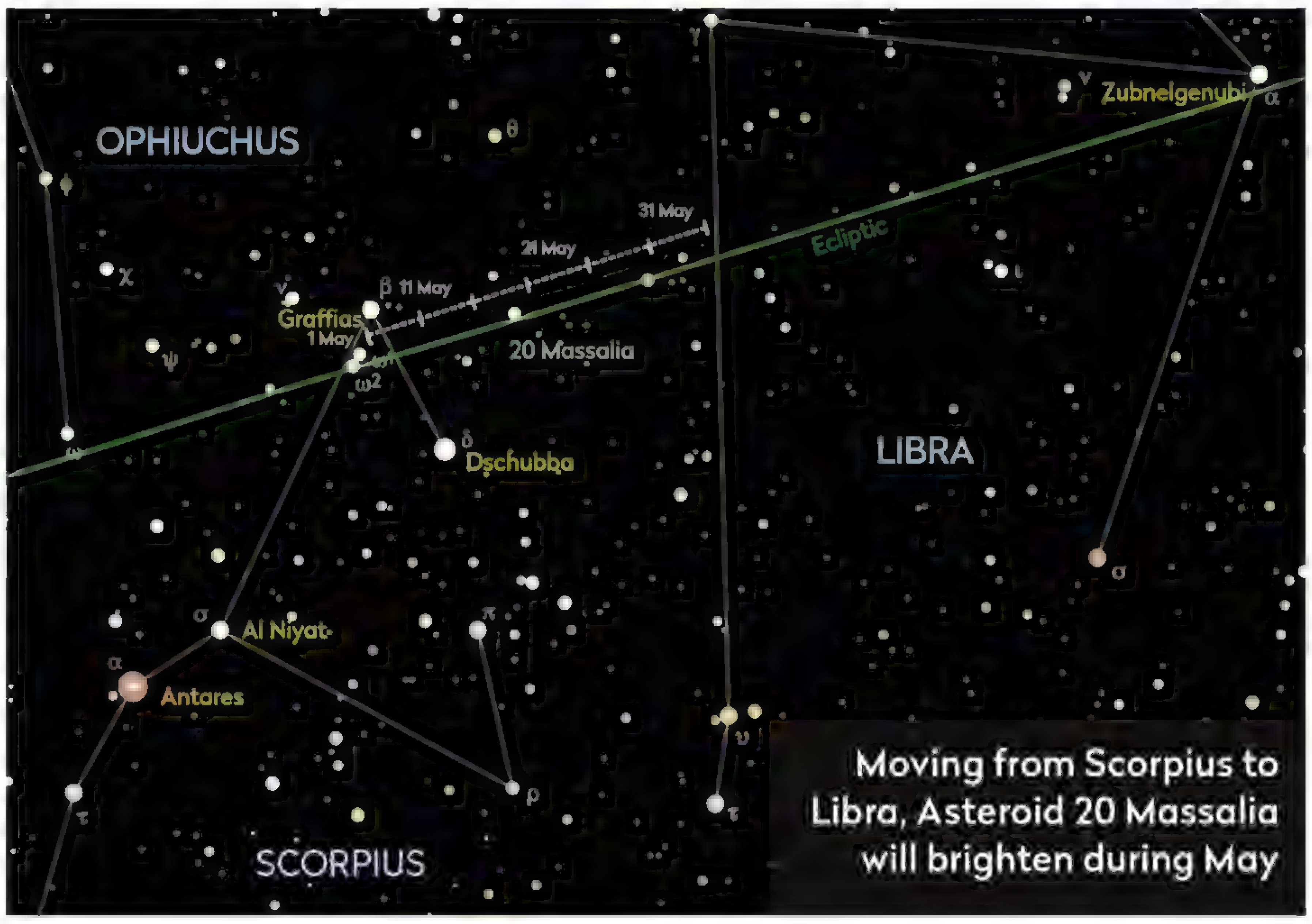
If you're an imager, you may wish to capture the tiny groove carved into the lunar surface 25km to the northeast of the centre of Dionysius. This appears to have been formed from a number of small craterlets and runs perpendicular to the line of Dionysius's rays at this location.

There are only two satellite craters of merit worth mentioning. Situated 34km south-southeast of Dionysius is 3km Dionysius A. Then, located 46km west and slightly north of Dionysius is 4km Dionysius B. Both of these features will require a 200mm or larger telescope to see.

COMETS AND ASTEROIDS

Look to Scorpius and Libra to spot rocky Massalia

Asteroid 20 Massalia reaches opposition this month in the constellation of Libra, the Scales. Massalia begins the month in Scorpius, located a fraction north of the pair of stars Omega[1] and Omega[2]. It then edges west parallel to the ecliptic, slipping across the border into Libra on 5 May, where it remains for the rest of the month. At the start of its track in Scorpius it shines at mag. +10.2. It then gradually brightens towards the point where it reaches opposition on 20 May, reaching a peak magnitude of +9.7. After opposition it gradually decreases in brightness to end the month at mag. +10.1.



Moving from Scorpius to Libra, Asteroid 20 Massalia will brighten during May

Massalia orbits in the inner part of the main asteroid belt and is the parent body of a large group of asteroids known as the Massalia family. There are in excess of 6,000 Massalian asteroids in this family.

Massalia is a fairly large S-type, or stony, asteroid, with a mean diameter of 145km. Its orbital period is three years, nine months and its mean distance from the Sun is 2.41 AU (361 million kilometres). At aphelion it sits 2.75 AU from the Sun, moving in as close as 2.07 AU at perihelion. Massalia rotates on its axis once every 8.1 hours. Its apparent magnitude ranges from +8.3 to +12.0 and it is believed to have a near spherical shape with triaxial ellipsoid dimensions of 160x145x132km. It is also thought that there are large flatish areas on its surface.

Massalia was discovered by the Italian astronomer Annibale de Gasparis on 19 September 1852, using the Naples Observatory. Interestingly, it was discovered independently on the following night by the French astronomer, Jean Chacornac at the Marseilles Observatory. Massalia became the first body in the Solar System to be given a non-mythological name.

STAR OF THE MONTH

Rasalhague, the brightest star in Ophiuchus

At the top of Ophiuchus, the Serpent Bearer, representing his head, is Rasalhague (Alpha (α) Ophiuchi). Close by is Rasalgethi, the head of another giant in the stars, Hercules, the Strong Man.

Rasalhague is a binary star system, 48 lightyears from Earth. It has a faint companion, too close to its primary for amateur instruments to see. The primary is estimated to be 2.4 times as massive as the Sun, while the secondary has about 85 per cent of the Sun's mass. The orbital period is 8.62 years and at the last periastron (where both stars were at minimum separation) in 2011, they appeared separated by just 50 milli-arcseconds.

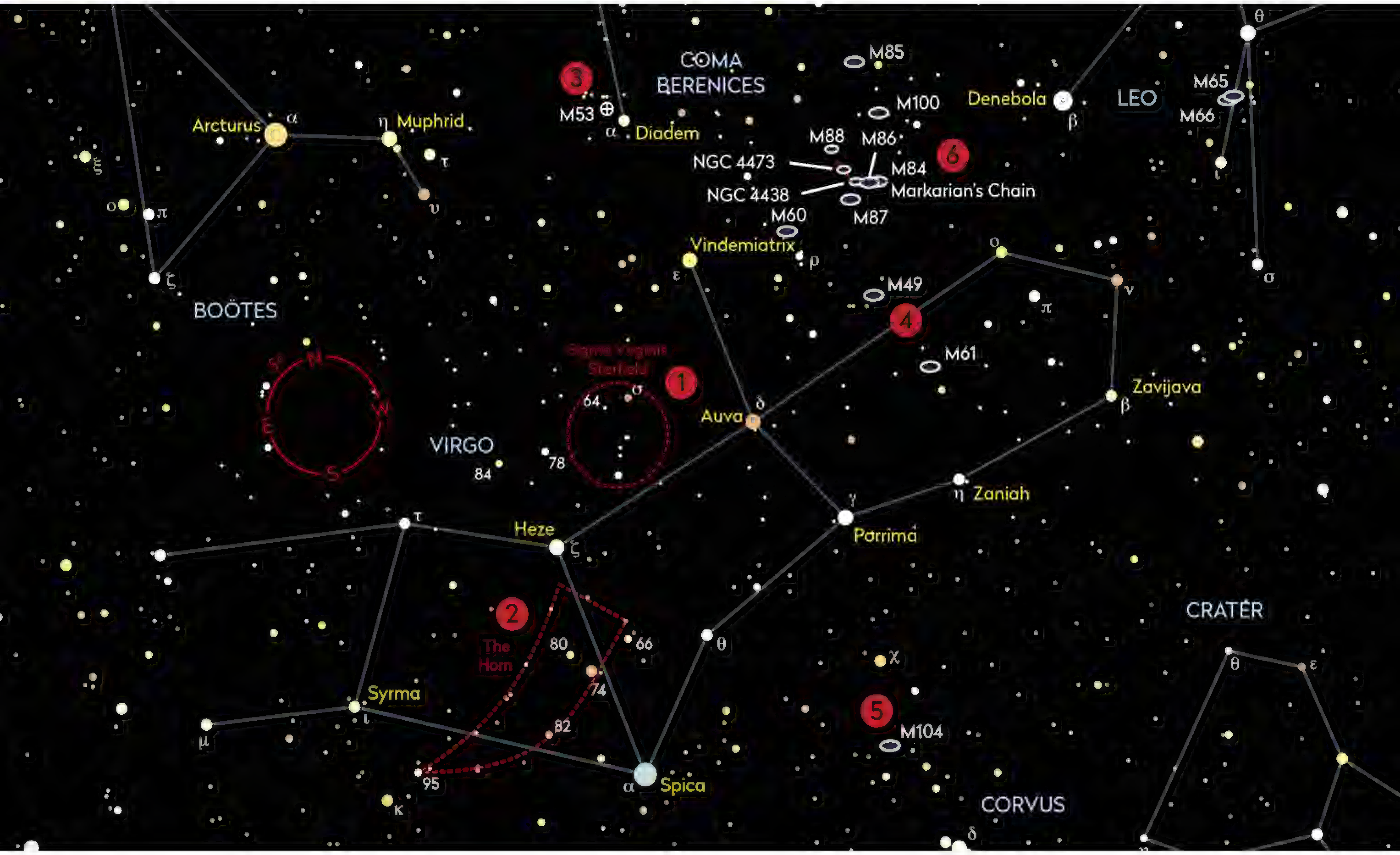
Rasalhague appears to shine at mag. +2.08 and has a spectral classification of A5 III – a giant star (the 'III' part) that has exhausted the hydrogen fuel at its core. Its companion is redder, with an estimated spectral class of K5 V.

Rasalhague is a fast rotator too, spinning at 240km/s. For comparison the Sun's rotational velocity is a rather leisurely 2km/s. At such a speed Rasalhague is close to its break-up speed of 270 km/s and will be bulging noticeably at its equator. An effect known as 'gravity darkening' will also be causing the star's poles to be hotter than its equator. Current estimates suggest the equatorial radius is 20 per cent larger than the polar radius. We get to see the star almost sideways on, its rotational axis being inclined to our line of sight by around 88°.

▲ **Rasalhague rotates extremely quickly, 120 times faster than our Sun**

BINOCULAR TOUR With Stephen Tonkin

The Sombrero Galaxy and Sigma Virginis starfield are among the wide-field highlights



1 Sigma Virginis Starfield

10x50 Low power binoculars are useful for scanning large starfields, so that's where we'll begin our tour. Find the orange-red mag. +4.8 Sigma (σ) Virginis and keep it at the north of your field of view. Filling the field are dozens of fainter stars, the brightest of which is the white, 6th magnitude 64 Virginis which is 1.2° east of Sigma. Notice how they are arranged in groups, with several pairs of similar brightness. The most notable is the 7th magnitude optical double 1.8° south of Sigma. ☐ **SEEN IT**

2 The Horn

10x50 Look 2° northwest of Kappa (κ) Virginis for a tight trio of stars, the brightest of which is 95 Virginis. This marks the point where two irregular long arcs of stars converge to create a horn-shaped asterism of 5th to 7th magnitude stars that sweep for about 12° to the northwest. ☐ **SEEN IT**

3 M53

10x50 Next is a faint-ish, easy to find globular cluster: M53. First, you need to identify Diadem (Alpha (α) Comae) and hop a degree to the northeast. Here you will find a small circular misty patch, which we will use to practice a useful technique: averted vision. Centre it in your field of view and direct your gaze back to Diadem or beyond. Notice how the misty patch seems to grow and brighten; this technique will be essential later in the tour in our hunt for faint galaxies. ☐ **SEEN IT**

4 M49

10x50 Our first galaxy is the elliptical radio galaxy, M49. Start by locating Rho (ρ) Virginis (mag. +4.9) and placing it on the northeast of your field of view; towards the opposite side of the field you will see a pair of 6th magnitude stars separated by a bit less than 1.5° and orientated southeast-northwest. M49 is the small smudge of light between these two stars. ☐ **SEEN IT**

5 The Sombrero Galaxy

15x70 The Sombrero Galaxy, M104, has a greater surface brightness than M49, but can be more difficult to see because it is 20° nearer the horizon. If you are going to have a chance with the Sombrero, sky conditions should enable you to see mag. +4.6 Chi (χ) Virginis with your naked eye. The galaxy is where a line south from Chi (χ) intersects a line west from Spica (Alpha (α) Virginis). ☐ **SEEN IT**

6 Markarian's Chain

15x70 You'll need dark skies for Markarian's Chain, a spring binocular delight. This galaxy chain lies mid-way between Vindemiatrix (Epsilon (ε) Virginis) and Denebola (Beta (β) Leonis). Start with M84 and M86, which are the brightest members and, once you have identified those, you should be able to find the chain's seven brightest galaxies. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Taking a spring journey around the riches of Virgo's galactic treasures

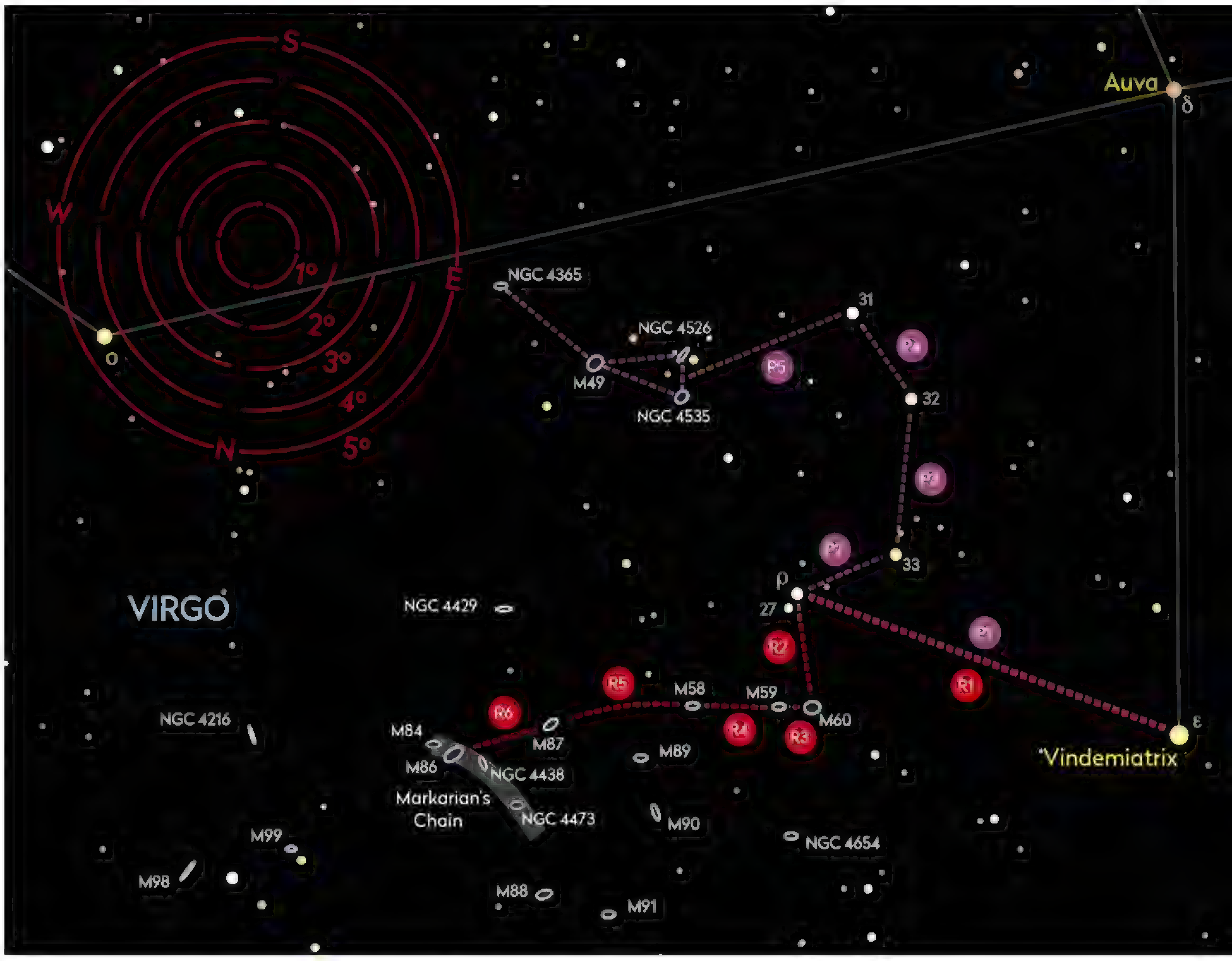
The technique of starhopping is an established method for navigating the night sky. By creating imaginary shapes, you can judge distance and direction to other shapes or objects. The shapes are yours to define and there are no rules as to how big, small or complex they can be.

Simple geometric patterns such as lines, triangles or squares are easiest. If you've never star hopped before, look up at the night sky on a clear night and work out how you would move from one bright star to another using your own custom-made pattern system.

This month's task takes this process one step further. The region of sky north of the Bowl of Virgo is known as the Realm of Galaxies because it's littered with examples. The challenge is to use galaxies, rather than stars, to locate other galaxies.

To do this we'd recommend using a telescope of at least six inches aperture. Galaxies are diffuse objects, so the larger the aperture the easier they are to see. Use a low-power eyepiece and ensure your eyes are properly dark-adapted.

We recommend starting at mag. +2.9 Vindemiatrix (Epsilon (ε) Virginis), the easternmost star in the Bowl of Virgo. Slew 5° west and fractionally south to locate mag. +4.9 Rho (ρ) Virginis, easily recognised with mag. +6.2 27 Virginis north-northwest of it.



▲ The red route takes you to Markarian's Chain and the purple route leads to galaxy NGC 4365

From Rho there are two routes shown on the chart above. Red 2 (R2) takes you to M60, with M59 immediately next door (R3). Extend the line from M60 through M59 (R4) to eventually arrive at M58. The next leg (R5) requires a slight northward curve, travelling about the same distance as that between M60 and M58 to arrive at M87. Keep the line going, straightened slightly (R6) to arrive at M86, part of a beautiful arrangement of galaxies known as Markarian's Chain.

The purple route starts the same way (P1), but then hops to mag. +5.7 33 Virginis (P2), mag. +5.2 32 Virginis (P3) and finally to mag. +5.6 31 Virginis (P4). The last leg (P5) is crucial because here you have to turn by 90° to head northwest by around twice the distance between 32 and 31 Virginis, arriving at a triangular arrangement of galaxies: NGC 4535, NGC 4526 and M49. NGC 4365 should be easy to hop to from this triangle too.

Stars are shown to magnitude +8.0 in our chart, while some galaxies approach magnitude +12.0. As a consequence, expect some fainter stars to add to the confusion. However, with patience and clear skies, the techniques shown here should allow you to explore this fascinating area and discover its amazing wealth of galactic treasures.

Markarian's Chain is a beautiful curve of galaxies

DEEP-SKY TOUR

A clutch of four globular clusters near Antares, plus the beautiful Blue Horsehead Nebula

▲ **An inverted view of IC 4592 – the Blue Horsehead Nebula – against a dark sky, will reveal its equine features**

KONSTANTIN VON POSCHINGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

1 M4

Messier 4 is one of the easiest globular clusters to find, yet one of the trickier ones to view well. It is located 1.3° west of Antares (Alpha (α) Scorpii) and forms the downward-pointing apex of a squat isosceles triangle with Antares and Sigma (σ) Scorpii as its base. The cluster shines at mag. +5.8 but only reaches 10° of altitude as seen from the centre of the UK. Its magnitude is misleading too. Only 7,200 lightyears away, the cluster appears quite large at around half-a-degree across, but this means its surface brightness is low and makes it very susceptible to light pollution interference. ☐ **SEEN IT**

2 NGC 6144

On paper, globular cluster NGC 6144 looks even harder to see than M4. It lies 0.6° to the northwest of Antares and shines at mag. +9.3. However, it appears smaller to us and so its surface brightness holds up fairly well. Having said that, a dark sky will, as ever, produce a better view. Use a low power to locate its 5-arcminute-diameter glow with Antares in the field. Slew to remove the distracting light of the red supergiant star, and increase magnification. At 100x it should be possible to resolve some of the outer stars. NGC 6144 doesn't show significant condensation, although its core region definitely looks brighter than the outer regions. ☐ **SEEN IT**

3 M80

Despite it also having a diminutive apparent diameter compared to M4, M80's visual magnitude of +8.5 means it has a brighter surface brightness and is consequently easier to see. It is located slightly less than half-way along the line from Sigma to Nu (ν) Scorpii. Globular density is measured on the 12-point scale known as the Shapley-Sawyer concentration class; the lower the number, the denser the globular. Where M4 has a value of 9, M80 scores 2. So despite being 28,000 lightyears distant, M80 appears brighter and easier to see than its better-known neighbour. M80 has a full apparent diameter of 10 arcminutes, although most stargazers will see something significantly smaller than this. ☐ **SEEN IT**

4 NGC 6284

We move further east for our final globular cluster, NGC 6284. This is in Ophiuchus, approximately 8° east and 1.8° north of Antares and is an even more remote globular at around 50,000 lightyears. It shines with an integrated magnitude of +7.4 and has a full apparent diameter of 6.2 arcminutes, typically appearing 2–3 arcminutes across through the eyepiece of smaller instruments. Despite its small and relatively bright appearance, this globular cluster's distance works against it; even relatively large scopes will struggle to resolve any of its stars. ☐ **SEEN IT**

5 IC 4634

Head 3° north of NGC 6284 and, with a slight nudge to the west, you'll arrive at planetary nebula IC 4634. It shines at mag. +10.9 and presents itself with a small apparent diameter of 10 arcseconds. At low powers it's very easy to mistake IC 4634 for a star, so it pays to be vigilant. Once you suspect you've identified it, gradually increase magnification. If it shows a small extended disc with elongation in a northwest-southeast direction, you have found your target. IC 4634 has a distinctly blue hue when viewed through larger instruments. An O-III filter will help greatly if you have one. ☐ **SEEN IT**

6 IC 4592

Our final target is the beautiful blue nebula IC 4592. To find it, return to our starting constellation of Scorpius and the fourth-magnitude Nu Scorpii. Once this star is in your field of view you'll be looking at the nebula. A low power around 20x is recommended, along with patience. It can be seen with smaller instruments but, as ever, the darker the sky, the better the view. Nicknamed the Blue Horsehead Nebula, when viewed inverted it appears like a giant horse's head looking west, with the bridge of its nose running northwest-southeast. Nu forms the horse's eye. Images will make its equine nature very clear. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

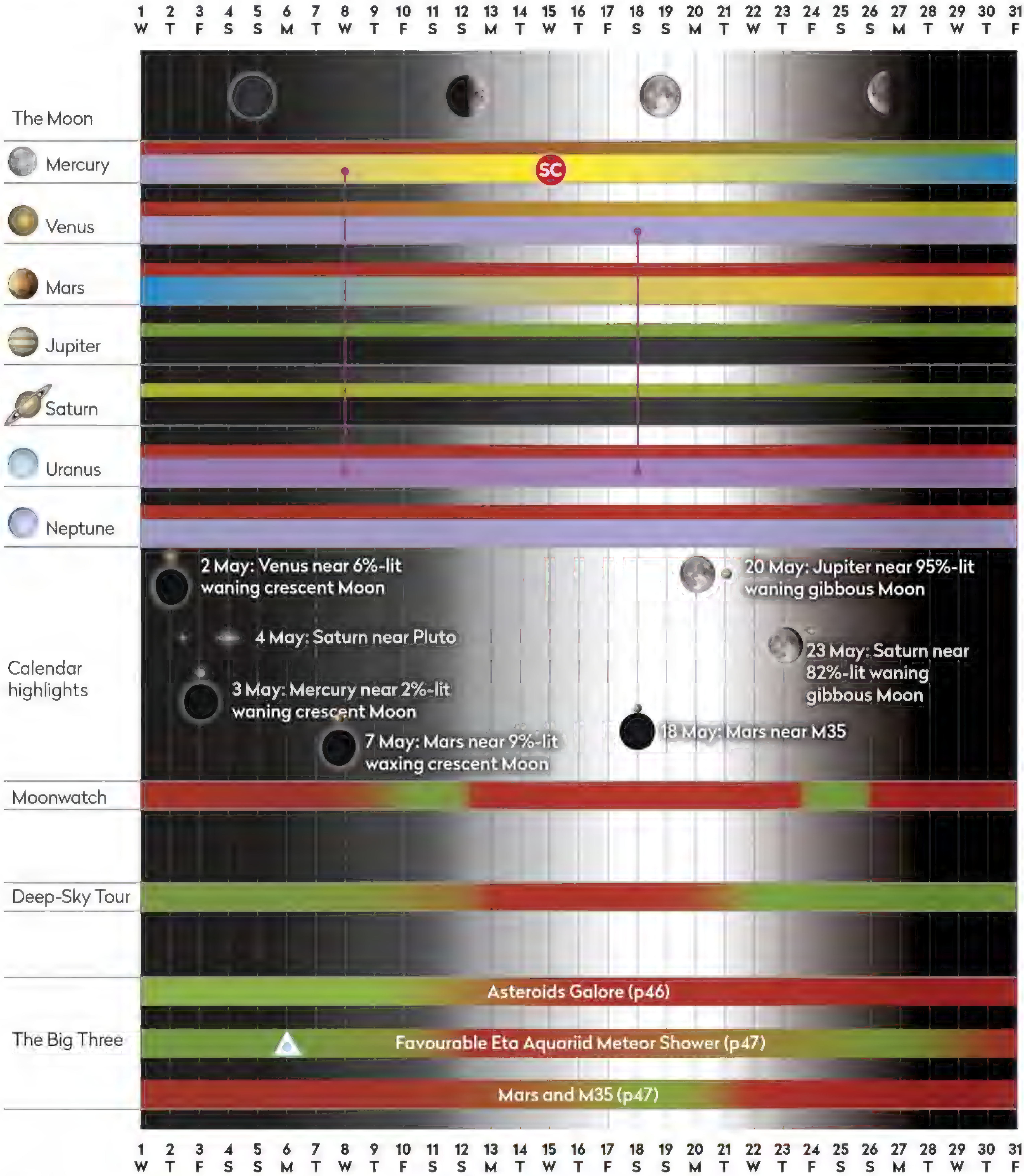
More **ONLINE**

Print out this chart and take an automated Go-To tour. **See page 5 for instructions.**

OPHIUCHUS
SCORPIUS
Ecliptic
Graffias
Al Niyat
Antares
IC 4592
IC 4634
NGC 6235
Collinder 302
NGC 6287
M80
IC 4604
NGC 6284
IC 4605
NGC 6144
M4
M19
NGC 6293
NGC 6316
5°
2°
N
E
S
W
16h30m
17h00m
-20°
-25°

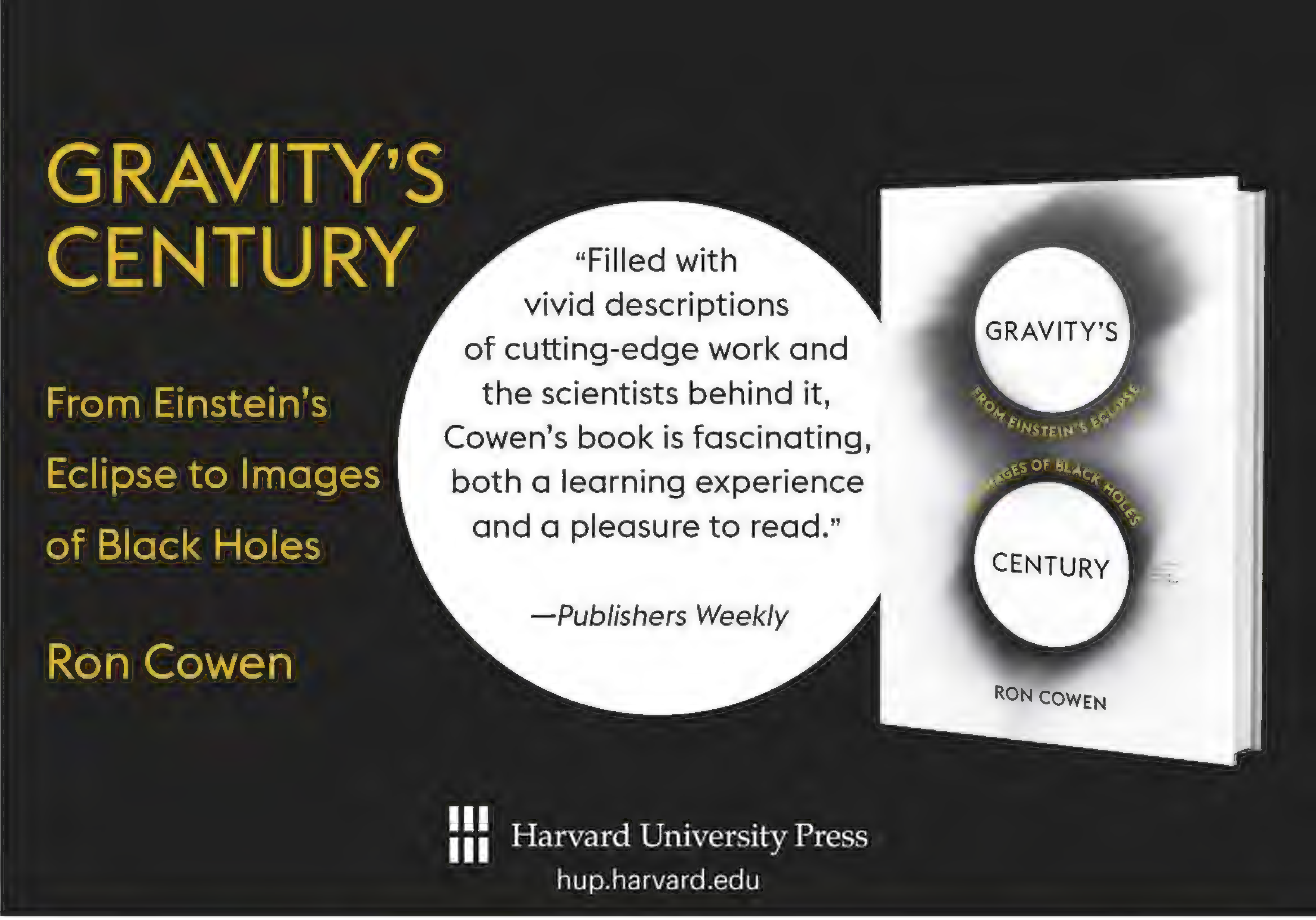
AT A GLANCE

How the Sky Guide events will appear in May



KEY

CHART BY PETE LAWRENCE


GRAVITY'S CENTURY
From Einstein's Eclipse to Images of Black Holes
Ron Cowen
"Filled with vivid descriptions of cutting-edge work and the scientists behind it, Cowen's book is fascinating, both a learning experience and a pleasure to read."
—Publishers Weekly
GRAVITY'S
FROM EINSTEIN'S ECLIPSE
IMAGES OF BLACK HOLES
CENTURY
RON COWEN
Harvard University Press
hup.harvard.edu


Tring Astronomy Centre
The Home Counties Astronomy Specialists
Tel: 01442 822997
The UK's friendly Experts
with over 100 telescopes & binoculars on display
• Great prices and value
• Friendly face-to-face advice
• Extensive range of binoculars & spotting scopes
• One of the UK's largest displays of telescopes
• Excellent aftersales support
• Beginner package deals
8" ROWE ACKERMANN SCHMIDT ASTROGRAPH (RASA 8) f/2.0
CELESTRON CGX-L EQ mount and tripod 75lb load capacity 144mm diameter worm wheels 270mm dovetail saddle
ZWO ASI294MC Pro (colour) USB3.0 Cooled Camera
SKY-WATCHER EQ6-R Pro Synscan GOTO EQ mount
DAYSTAR INSTRUMENTS QUARK* Hydrogen Alpha eyepiece
Visit our website for prices and all our latest Special Offers
Showroom open 5 days a week - Free on-site parking
Tring Astronomy Centre Ltd, Unit 10 Silk Mill Business Park, Brook St, Tring, Herts, HP23 5EF
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www.tringastro.co.uk
enquiries@tringastro.co.uk

Well-chosen accessories can transform your stargazing, helping with navigation and getting the best view through your scope

A buyer's guide to TELESCOPES

PART 2: Astronomy accessories

In the second of our three-part telescope guides, **Tim Jardine** looks at the accessories that will enrich your astronomy experience

ZUMA PRESS, INC./ALAMY STOCK PHOTO

Tim Jardine is an experienced amateur astronomer and astrophotographer

▸ A weather-proof planisphere, with two adjustable discs, is a traditional option for navigation

Proud owners of new telescopes often spend their first few stargazing sessions zipping all around the sky, moving quickly from object to object. This can be a very exciting time, and experiences like seeing Saturn's rings for the first time are not easily forgotten.

However, once we start to really explore the vast night sky, it becomes obvious that there is more to it than just looking up through a telescope if we want to observe the most interesting things hidden among the stars. Thankfully, there are many accessories available to help. We can break these down into three groups: accessories that make the sky easier to navigate, gadgets that can improve your view through a telescope, and those that make for an overall more enjoyable experience.

There are thousands of fascinating objects to see while observing, but finding them can be tricky. Even computerised telescope mounts, which automatically locate objects, need aligning on known stars before they can accurately locate targets. Manually operated telescopes rely on the user being able to find the target themselves, of course.

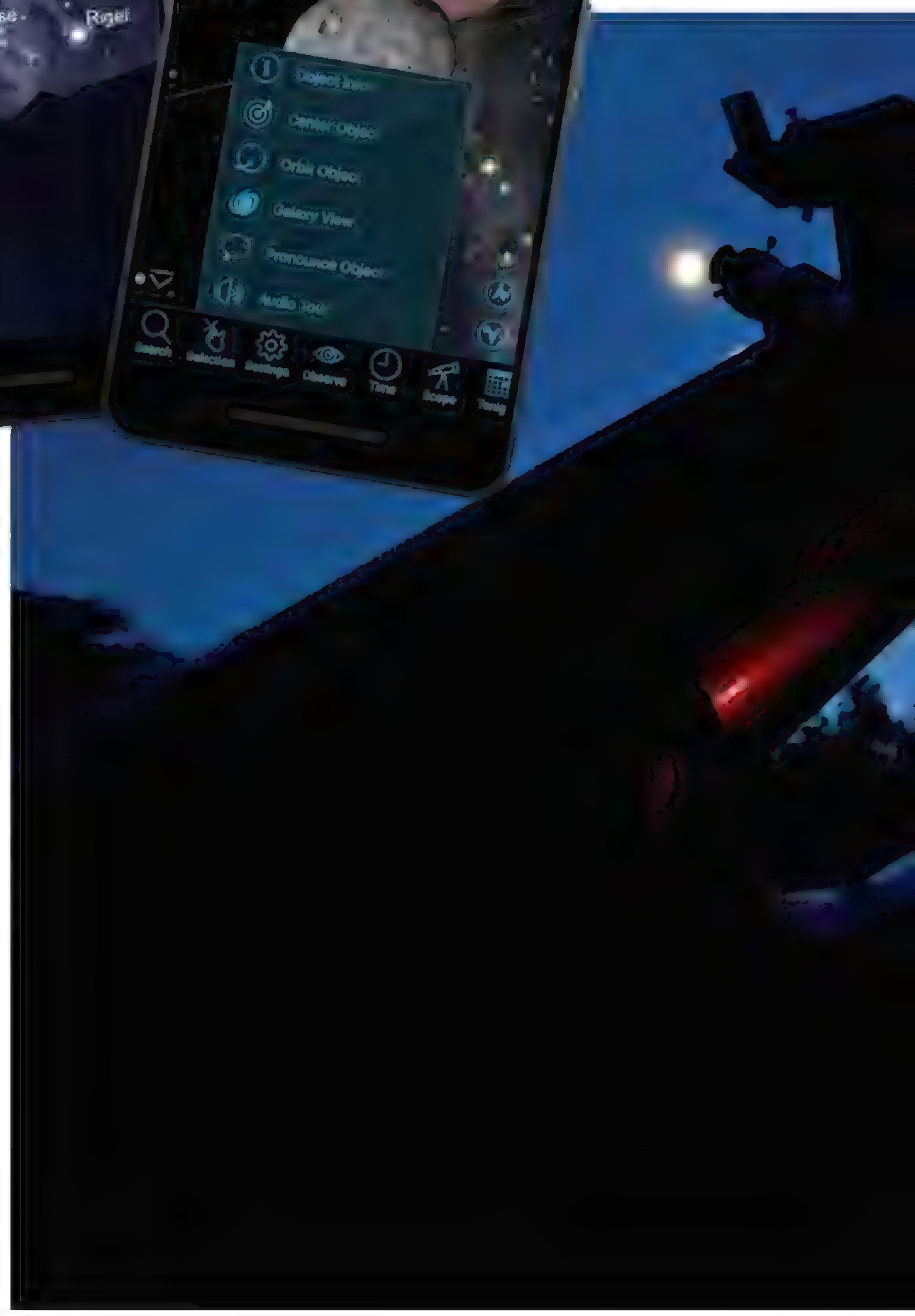
Accessories that can help here are star atlases, planispheres, smartphone apps and finderscopes, all of which make it easier to point your telescope in the right direction.

Finding your location

Planispheres are the most basic device for recognising the constellations in the night sky and offer a cheap and traditional option for star navigation. Choose one made from weatherproof plastic that is readable at night under red light – as this won't spoil your dark-adapted vision – and which is calibrated for your observing latitude.

Sky maps or star atlases act as a point of reference while stargazing, and also before and after the session. They're helpful for planning what you'd like to see in an evening and revealing how to actually find the objects using nearby stars for reference. Plus, when you stumble across an interesting object, star maps make it easier to determine what you're actually looking at. While they range from fairly

▴ Smartphone apps such as SkySafari will help you find the best objects to observe while you are viewing the sky



▸ Star atlases are useful for planning and sharing what you intend to locate during a session

A good astronomy app should have a night vision-friendly red light option and be easy enough to operate even with cold fingers

◂ A Telrad finderscope is an invaluable aid for helping you to locate your target in the night sky

▾ Laser pointers are useful but must be used with care

straightforward and easily followed maps to extremely detailed documents with thousands of bits of information, any good star atlas should be easy to read at night (again, by red light), contain major objects of interest and offer helpful tips or more detailed maps for trickier objects.

Becoming increasingly popular, astronomy apps for smartphones and tablets make use of GPS to display the appropriate night sky according to the precise time and exact location that you are stargazing. Unlike books they can be updated frequently to provide information for interesting events like eclipses, comets or even asteroids. Many of these apps have a free version, with paid-for upgrades offering more functionality. A particularly useful feature of these apps is the ability to zoom in and out on a target, revealing its position from a wider perspective and making it easier to find with your telescope. Firm favourites among astronomers are the free software Stellarium (www.stellarium.org), which offers a realistic view against the horizon, and SkySafari (www.skysafariastronomy.com) which details the best objects to see that night, reveals information about them, and makes them easier to find. Some objects have photographs included to give an idea of what you are looking for. A good astronomy app should have a night vision-friendly red light option and be easy enough to operate even with cold fingers.

Target practice

With a target decided on and its position in the sky determined from an app or star atlas, the next trick is to accurately point the telescope in the right place. Typically, the finderscopes that are included with new telescopes offer a wide view with a central crosshair, but to anyone unfamiliar with the sky, the view can still be confusing.

Some accessories make it easier to see where the telescope is pointing without squinting through a small finderscope. An example is a laser pointer, although extreme care needs to be taken when using them, and they may be unpopular with other astronomers as they can disrupt the view of the night sky. A Telrad finderscope on the other hand safely projects a dimmable reticle onto a screen, and many amateur astronomers find them invaluable aids to night sky navigation.

With the target in sight, we need to be sure that we are enjoying the best view possible. Some of that will come down to eyepiece choice, which we will deal with in part three of this guide in next month's issue. Many newcomers to stargazing will start out observing the Moon or bright planets like Jupiter and ▸

◂ Eyepieces, Barlow lenses and filters will enhance your viewing

▸ Saturn. The Moon can be quite dazzling to observe, especially near full illumination, and observation is easier through a Moon filter. These screw onto the front of an eyepiece and reduce the glare, and are among the most popular accessories. While the Moon is very bright, planets can appear very small, so another favourite choice is known as a Barlow lens; an extra magnifying lens that goes in front of an eyepiece and enlarges the view. The Moon and the planets are natural candidates for increased magnification, and extra details may be seen on their surface. A nice Barlow lens can effectively double your eyepiece collection, but remember that there is a limit to useful magnification dictated by your equipment and sky conditions.

Getting in line

Getting the very best views from some telescopes may involve a bit of maintenance and reflectors, including Dobsonians, will likely need to be collimated periodically to produce the sharpest views. Collimation is the process of accurately lining up the telescope mirrors. Poorly-aligned optics can produce odd-shaped stars and soft planetary views. Although the process sounds daunting, it is made simpler with accessories like a Cheshire collimator, or devices that use a reflected laser beam. Video tutorials providing useful instructions can often be found online.

An enjoyable stargazing session can be prematurely cut short if the telescope succumbs to dew, and all varieties of scope can be affected. A simple dew shield that acts as an extension of the main tube can offer some protection and helps improve views by blocking stray light. Alternatively, electronic dew controllers powered with a 12V supply provide a proactive stance against dew, with an adjustable power output connected to heated straps that gently warm the optics to prevent dew forming on them.

Some accessories really help to improve the overall enjoyment of a good observing session. A dedicated observing chair with adjustable height, for instance, is useful for keeping comfortable for the duration. Being able to relax while observing means you are more likely to spend longer at the eyepiece, which in turn means you are more likely to spot extra details and features on your target. While observing chairs can be purchased, they can also be constructed from simple plans (see www.skyatnightmagazine.com/observing-chair for our own).

Where a low voltage electricity supply is required, perhaps for electronic mounts or dew control apparatus, portable battery packs are available with

◂ A Cheshire collimator will help keep your scope's mirrors lined up

▴ Warm your scope to keep it free of dew with an electronic dew controller

▸ Build your own observing chair for added comfort while you observe

The Moon can be quite dazzling to observe, especially near full illumination, and observation is easier through a Moon filter

PAUL WHITFIELD X 4, MARK PARRISH, CELESTRON, TELEGIZMO

An astro-gadget guide

From a Moon glare filters, to a long-life power source, we select the most useful pieces of kit to help your stargazing

Moon Filter

£31 • www.
firstlightoptics.com

The Baader Neutral Density Moon Filter is available for both 1.25- and 2-inch eyepieces and will reduce glare from the Moon and planets. Choose an appropriate density to suit your telescope.

TeleVue 2x 1.25-inch Barlow lens

£112 • www.
astroshop.eu

With 2x magnification this premium quality Barlow lens makes a 10mm eyepiece act like a 5mm, and so on, without degrading the view. The TeleVue gave the best performance in our own tests.

Celestron Powertank Lithium

£119 • www.
celestron.com

More environmentally friendly than lead acid batteries, with a long life and 2,000 charge cycles, this power tank provides 12V power to mounts and accessories, with USB charging and red or white lighting options.

Telrad Finder

£38 • www.
365astronomy.com

A battery-powered Telrad reflex sight is mounted atop your telescope and displays calibrated circles against the night sky. The larger circle shows the area covered by a standard finderscope, while the smaller shows the area in the eyepiece.

Turn Left At Orion

£22 • www.
cambridge.org

There are many observing guides on the market and *Turn Left At Orion* is one of my favourites. It is useful for owners of typical home telescopes and Dobsonians, whether astronomy newcomers or seasoned observers.

◄ A weatherproof scope cover allows you the option of dismantling your scope in daytime

▼ A red light torch will enable you to read star maps and move around safely at night

outputs needed for a typical telescope setup. Recent improvements in battery technology and practical additions like USB charging points make these packs very useful accessories.

Over time, glass telescope lenses and eyepieces may require gentle cleansing, and microfibre cloths along with a specialist product like Baader Optical Wonder fluid can remove marks without leaving residues.

A good red torch is pretty much essential while observing. Red light has the least impact on our eyes' adaptation to the dark and can be used to read star maps and move around safely at night. The less light the better, so look for dimmable torches.

At times it may be preferable to leave equipment set up outside, either overnight or for longer periods. Weatherproof telescope covers are available to fit most equipment and can be simply attached over the telescope after use. This may enable subsequent sessions without having to re-do alignments, or just make it easier to dismantle equipment in the daylight.

Whichever telescope you use, and whatever you like to observe, there are always extra accessories to help you get more out of your stargazing sessions.

Next month

Part 3: getting the most out of your new telescope

The fundamentals of astronomy for beginners

EXPLAINER

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Solar astronomy

Our nearest star can provide some of the most outstanding astronomical views

Astronomy is something you usually associate with the dark, so the Sun can be easily overlooked as an astronomical object for observation. However, with the right equipment and a simple safety routine, solar observing can be one of the most visually rewarding observation projects in amateur astronomy.

One of the easiest things to view is the sunspots on the Sun's visible layer, the photosphere. It's important to never look directly at the Sun through a telescope directly, as you can damage your eyesight. Likewise, you should never look directly at the Sun with sunglasses or darkened glass as these do not block out the most harmful wavelengths of light.

However, you can safely project the Sun's image through a telescope. It's usually a refractor as the intense heat can damage some other types of telescope. With the dust cap on your telescope to stop harmful stray light, place a square of white card behind the telescope eyepiece and adjust the scope until the instrument's shadow is rounded on the card; only then remove the dust cap and the Sun's image should be projected onto the card. If not, adjust the telescope slightly until it appears but remember to never look down the eyepiece directly.

▲ A refractor can be used for projecting the Sun's image onto a white card

Sunspots in the photosphere can be seen with a white light filter

ALL PICTURES: PETE LAWRENCE

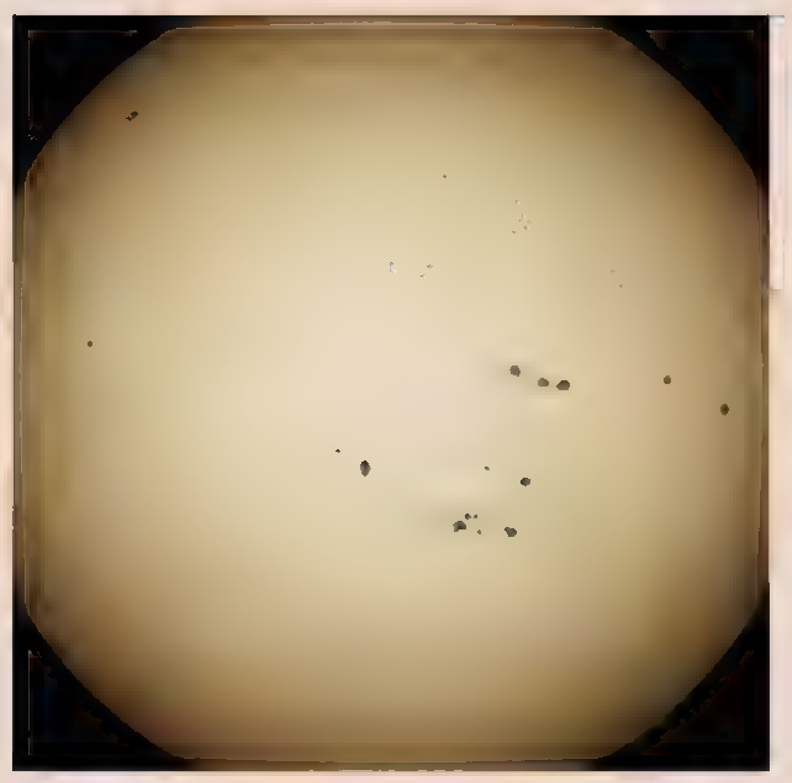
Using solar filters

White light observing is generally the study of the solar photosphere where dark sunspot groups are found and bright patches called "faculae" are seen more clearly near the solar limb. As an alternative to solar projection, you can also equip your telescope with a glass white light filter which will allow you to look directly through your telescope at the photosphere to see sunspots in fine detail. Such filters can be purchased from any reputable astronomy retailer and fit on the objective end of your telescope. If cost is an issue you can make your own, though it's vital to use certified solar safety film and make sure the final filter has no holes or gaps in it.

However, it is the solar atmosphere or chromosphere where the real action takes place. This can be seen by using a special solar filter which only allows light through towards the red end of the spectrum known

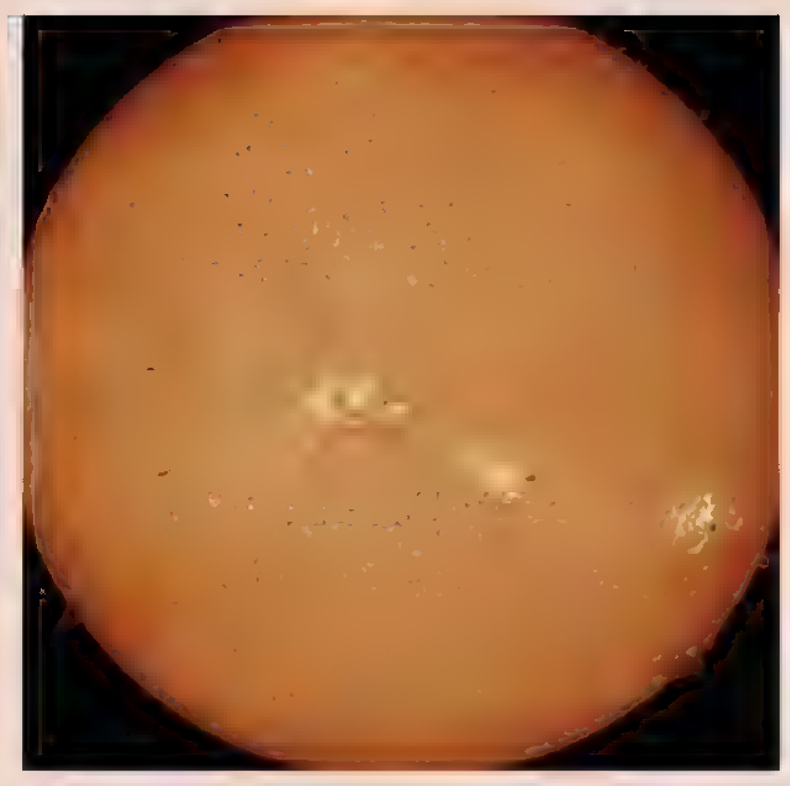
7 solar features

From sunspots to solar flares, here's our pick of the Sun sights to look for



PHOTOSPHERE

As the Sun is gaseous, we refer to the photosphere as the Sun's surface. This is the area where light is released and where sunspots and faculae can be seen.



CHROMOSPHERE

A thin layer of solar atmosphere exists above the photosphere and below the corona. Hydrogen/alpha filters reveal its prominences, filaments, plage and flares.

SUNSPOTS

Sunspots are caused by magnetic fields creating patches of cooler plasma. Sunspots have a dark central area, the umbra, and a lighter outer area, the penumbra.

PROMINENCES

Visible on the solar limb, prominences are dense eruptions of plasma thrown outward from the chromosphere along magnetic field lines.

FILAMENTS

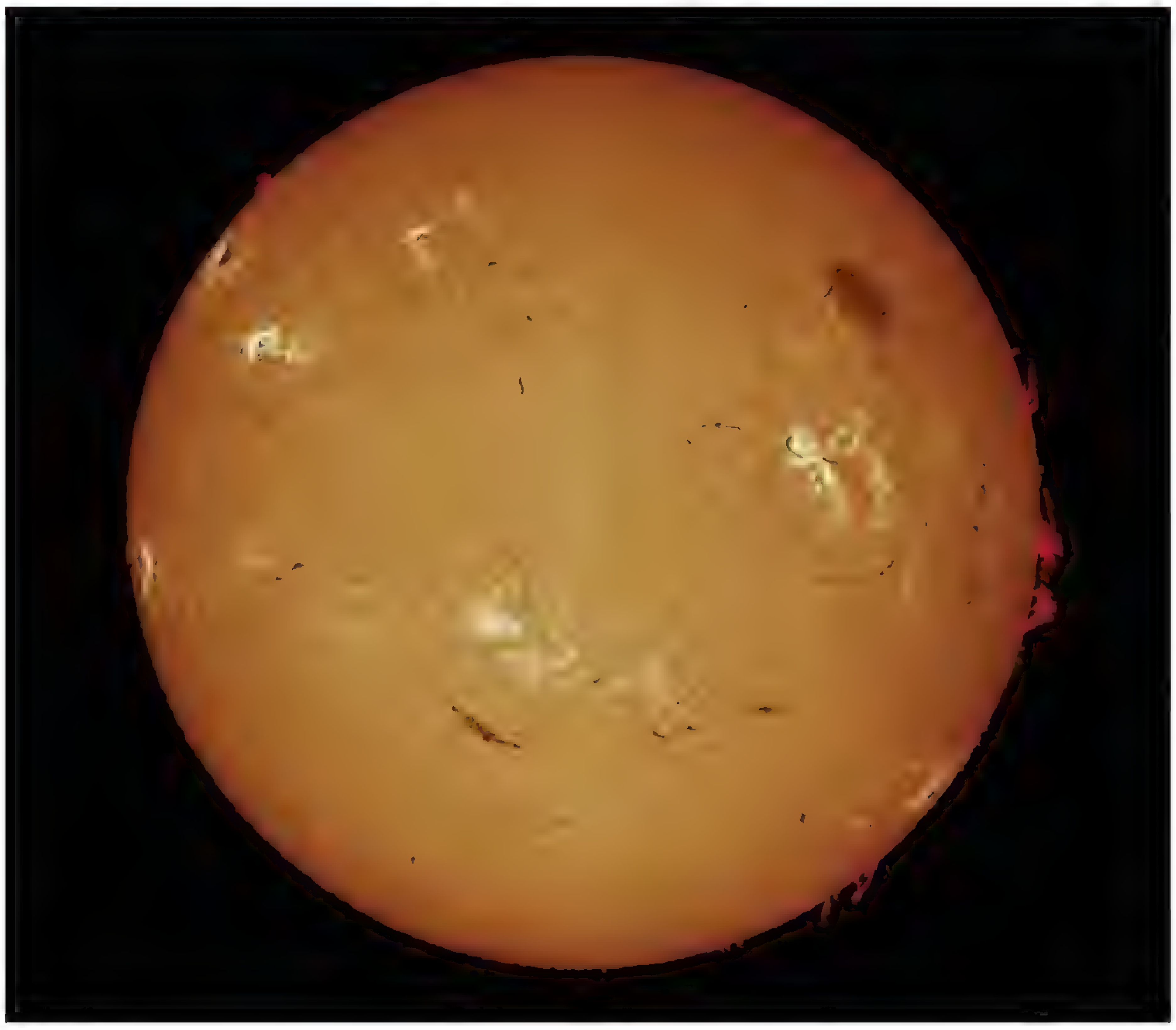
Seen as dark lines across the solar disk, filaments are the same hydrogen/alpha feature as solar prominences but viewed head on rather than extending sidewise into space.

PLAGE

Plage is a feature in the chromosphere, often seen in association with sunspot groups. Plage can be an indicator of where a sunspot is about to form.

SOLAR FLARES

Magnetic field lines break and re-connect, producing a release of energy. This event can be seen in hydrogen alpha as a brightening of the solar chromosphere.



▲ A hydrogen/alpha filter allows you to enjoy amazing views of solar features in the chromosphere

as a hydrogen/alpha filter. Here you can see solar prominences, filaments, plage and flares.

Solar prominences extend from the solar limb out into the darkness of space and are vast emissions of hydrogen travelling along magnetic field lines. Sometimes, the field lines can loop back down into the chromosphere or break, ejecting plasma into space. Prominences can be short- or long-lived features but the really fascinating ones are the short-lived eruptive prominences that can almost grow and twist as you watch them in real time. Dark filaments can also be seen in this wavelength, streaked across the solar disk. These are actually prominences but seen as dark features across the bright solar disk rather than bright features seen against the dark background of space hence another name to differentiate them.

The only down side is that hydrogen/alpha filters can be very expensive to purchase. You can either buy a specialist solar telescope, or a kit to fit your existing telescope. These have both an energy rejection filter that will reduce the heat entering your telescope and a blocking filter for the eyepiece. Coronado and Daystar produce the cheapest hydrogen/alpha telescopes, around the £700–£800 mark.

Lyn Smith is director of the British Astronomical Associations Solar Section. The BAA's website is updated regularly with images of solar activity. For more details visit www.britastro.org

APOLLO 10

Niamh Shaw takes a look at NASA's dry run to the Moon, just months before humanity attempted to land on the lunar surface

By May 1969, the US was almost ready to land on the Moon. Before NASA was willing to risk human lives on the landing, they wanted a dress rehearsal to make sure that everything was ready to go. That mission was Apollo 10. Over eight days, the crew of Apollo 10 would perform a mission that was identical to the future lunar landing in every way bar one – they wouldn't touch down on the lunar surface.

It was the same mission duration as Apollo 11, with the same orbit and the same spacecraft, so what stopped NASA allowing Apollo 10's crew to land on the Moon? The main reason was that there were still some uncertainties surrounding calculations involving the moon's gravitational field, which needed further investigation. The powered descent guidance system on the lunar lander needed to be accurate to within one nautical mile (1.85km) for the eventual Apollo 11 landing to be successful. So there was still much to learn from this mission.

There was a risk here: a crew as capable and experienced as Apollo 10 might go rogue and attempt a landing anyway. After all, these were veterans of the Gemini programme and had been the back-up crew for Apollo 7. Thomas Stafford and Eugene Cernan could easily have grazed the Moon when testing the lunar module. And while NASA doubtlessly trusted the crew, this temptation had been factored into mission design. "A lot of people thought about the kind of people we were", said Cernan. "The ascent module, the part we lifted off the lunar surface with, was short-fuelled. The fuel tanks weren't full. So had we literally tried to land on the Moon, we couldn't have gotten off."

For Stafford, Young and Cernan, it was finally the chance to go beyond low-Earth orbit; to the Moon.

NASA X 13

MISSION BRIEF

Launch date: 18 May 1969

Launch Location: Launchpad 39B, Kennedy Space Center

Lunar Orbits: 31

Mission Duration: 8 days, 3 minutes, 23 seconds

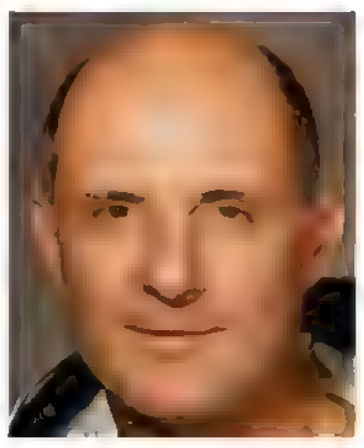
Return Date: 26 May 1969

Main goals: Dress rehearsal for Apollo 11

Firsts: Live colour TV transmission from space; highest speed by a crewed vehicle (39,897km/h); first human to fly solo around the Moon (John Young); shave in space

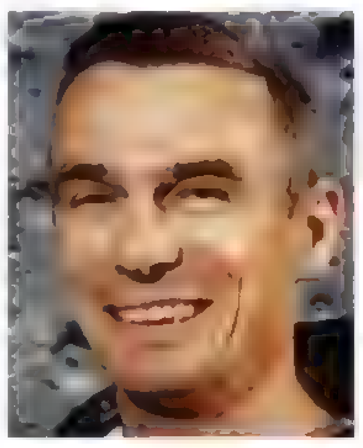
Menu: Beef and vegetables, pineapple fruitcake, orange-grapefruit drink, grape punch

Meet the astronauts



Commander: Thomas Stafford
Originally a US Air Force flight instructor, Stafford was selected for NASA's Gemini programme in 1962. He was back-up pilot for Gemini 3, pilot for Gemini 6 and command pilot for Gemini 9. After commanding Apollo 10, he commanded the Apollo-Soyuz Test Project in 1975, a joint US & Soviet space flight, before retiring.

Command module pilot: John Young
A navy test pilot before joining NASA in 1962, Young first flew in space on Gemini 3. After Apollo 10, he went on to be commander of Apollo 16 in 1972 and became the ninth man to walk on the Moon. He commanded the first and ninth Space Shuttle launches, in 1981 and 1983, both aboard Columbia. He died in 2018 aged 88 years.



Lunar module pilot: Eugene Cernan
Pilot Gene Cernan joined NASA in 1963. His first space mission was Gemini 9 in 1966 when he made the second American spacewalk. After Apollo 10, he returned to the Moon in 1972 as commander of Apollo 17 and became the final astronaut to walk there – the last of only 12 people to have walked on another world. He died in 2017 aged 82.

▲ Thomas Stafford holds up a picture of Charlie Brown in a spacesuit to the camera during a TV transmission

▲ Weightlessness was demonstrated by pushing an upside down John Young up and down

"Gee, I'm really getting vertigo here." – Thomas Stafford, drifting over the Moon in 'Snoopy'

A sizeable achievement in its own right and for them, that was enough. They were a team after all, and they hoped that their chance to walk on the Moon would come later. Indeed, Cernan became the last man on the Moon, as part of the Apollo 17 mission. Every element of Apollo 10 was about final checks, and the crew was committed to fulfilling this brief.

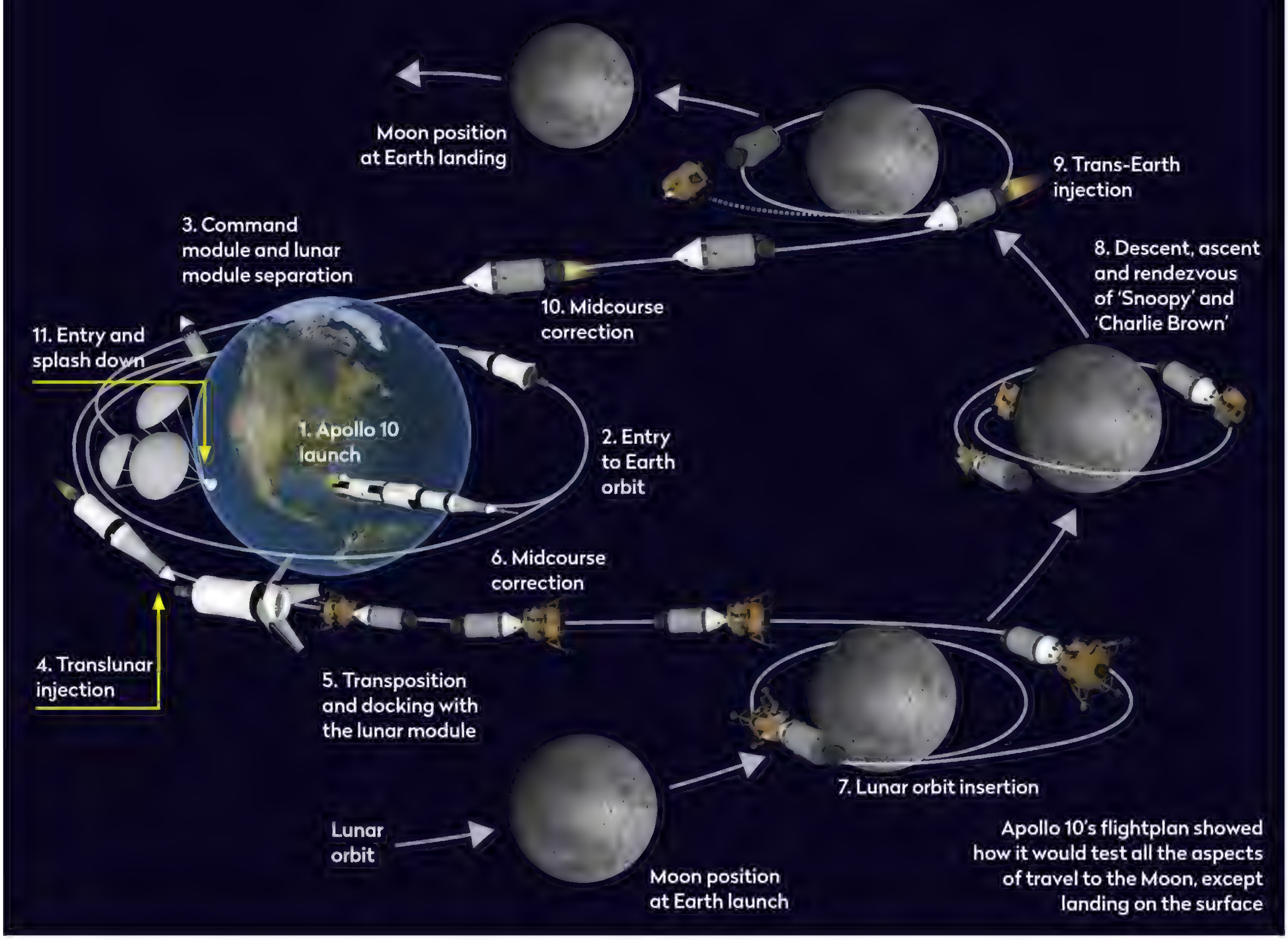
Successful lift-off

Apollo 10's launch into lower-Earth orbit went without incident. A little over two and half hours later, after 1.5 Earth orbits, the translunar injection was initiated, increasing the speed of the spacecraft to the velocity required to escape the gravitational attraction of Earth. Shortly afterwards, the crew transmitted the first colour broadcast from space as they extracted and docked with the lunar module, named 'Snoopy' in reference to the black and white caps the astronauts wore, which resembled the cartoon character. The command module was named 'Charlie Brown', continuing the theme.

Apollo 10's outward journey proceeded almost exactly as planned. Thanks to the gravitational drag of Earth, the 39,000km/h velocity at which it entered the lunar corridor was reduced to approximately 3,200km/h. Then, as the spacecraft entered the Moon's gravitational field, the pull of the Moon overcame the braking effect of Earth and the spacecraft picked up speed to a peak of 8,850km/h (relative to the Moon) just before entering lunar orbit. To achieve orbit, it was necessary to use the Service Propulsion System to slow the spacecraft's speed to roughly 5,800km/h and permit its capture by the Moon's gravitational field.

They arrived in lunar orbit on the third day. Refreshed by what Stafford termed "a great night's sleep" and feeling "just tremendous," the spacecraft commander played a tape of Andy Williams singing "Up, Up and Away!". They had time for TV broadcasts, where Cernan displayed drawings of Charlie Brown in space coveralls, and his toy beagle Snoopy wearing the scarf of a World War One fighter pilot. Stafford and Young were shown side by side, with Young upside down. To demonstrate the strange effect of weightlessness, Stafford would move Young up and down with little more than a light touch as Young joked, "I do everything he tells me." ►

► Apollo 10 launched on 18 May 1969 without any hitches



Apollo 10's flightplan showed how it would test all the aspects of travel to the Moon, except landing on the surface

▸ Food on this mission had improved a lot from previous Apollo missions and boosted crew morale as they travelled on their outward journey to the Moon: individually wrapped commercial bread and the ingredients for ham, chicken and tuna salad were added to the usual freeze-dried diet. However, the drinking water didn't go down so well, with a discernible after taste of chlorine with each gulp.

Flying over the Moon's surface

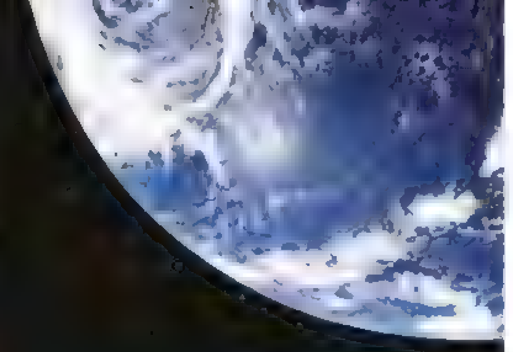
Then came Thursday 22 May, day four of the mission and the most action-packed. The time had arrived for lunar module 'Snoopy' to descend to the Moon. While Young remained in lunar orbit on 'Charlie Brown', Stafford and Cernan entered the lunar module and slowly backed it away from the command module. For the next eight hours, as Cernan and Stafford completed their checks, standing throughout, Young became the first person to fly solo around the Moon. It was mid-afternoon in Mission Control before everyone was ready and then around 9.35pm GMT, the descent engine fired, bringing 'Snoopy' closer to the Moon's surface than ever before. An hour later, Cernan excitedly commented, "Hello Houston, we is [sic] down among it!" They had reached 8.4 nautical miles (15.6km) above the Sea of Tranquility, Apollo 11's planned landing zone, all the while describing the lunar surface that was passing beneath them, giving

"You can't imagine the position we can see these things in... It looks like we're not very far above them. It's fantastic." – Thomas Stafford

▲ 'Charlie Brown' (left) and 'Snoopy' (right) just after undocking for Apollo 10's landmark approach to the Moon

NASA X 4, ILLUSTRATION BY PAUL WOOTTON

Dr Niamh Shaw is an engineer, scientist and analogue astronaut who has participated in Mars missions in Utah, US and Israel



MISSION TIMELINE

18 May 16:49*
Launch at Pad 39B, Kennedy Space Center.

18 May 19:28
Translunar injection begins.

18 May 19:51
Command module separates from the S-IVB engine. The command module docks with the lunar module.

18 May 19:55
TV coverage of docking procedures transmitted.

22 May 15:51
Cernan and Stafford cross over to the lunar module and activate systems.

22 May 19:00
Lunar module undocks.

22 May 20:35
Lunar module inserted into descent orbit.

22 May 21:30
Lunar module makes closest approach, 15km over the surface.

23 May 03:11
Lunar module redocks with command module.

24 May 10:25
Apollo 10 begins its return trip to Earth.

26 May 16:52
Crew splash down in Pacific Ocean and are recovered by *USS Princeton*.

*All times are GMT

The two modules 'Snoopy' and 'Charlie Brown' successfully redocked above the far side of the Moon

the landing radar a thorough checkout and conducting extensive surface photography and landmark tracking.

The lunar module flight was near flawless apart from one chilling moment, as they were preparing to disembark from the lunar surface. Due to a misaligned switch on the ship's abort guidance system, 'Snoopy' suddenly began to spin and gyrate wildly. Caught off-guard, Cernan shouted "Son of a b——!" live on the radio, across an open channel to the world. Thankfully control was regained after a few seconds, and the gyrating spacecraft returned to a normal ascent. A relieved Stafford announced to Mission Control, "We've got all our marbles."

The rendezvous with the command module went without incident. The two craft joined up on the far side of the Moon, and when the crew re-emerged, Stafford radioed, "Snoopy and Charlie Brown are hugging each other." To celebrate, Mission Control in Houston displayed a large cartoon showing Snoopy kissing Charlie Brown. After eight hours apart, Stafford and Cernan re-joined Young in the main craft. The lunar module was cast loose and fired its engine driving it into orbit around the Sun.

▲ Making a splash: Apollo 10 returns to Earth on 26 May

Friday 23 May was a day of relaxation and recovery for the crew in lunar orbit. They completed some landmark tracking and lunar photography and more TV broadcasts. When the camera focused on the crew, they had shaved: another first. Previous Apollo crews had ended the mission sporting significant stubble due to concerns that shorn hair might escape in the cabin and cause difficulties with the instruments. Apollo 10's crew avoided this by using tubes of shaving cream and capturing their scrapings in swabs. "We felt reborn," Cernan later recalled in his autobiography, *The Last Man on the Moon*.

As they left lunar orbit, with a velocity of 39,897km/h, they set a record for the fastest speed ever achieved by a human being. Apollo 10 splashed down east of Samoa on 26 May, and the crew were recovered and flown to Houston for de-briefing. A large sign had already been put up on Mission Control which read "51 days to launch". Focus had already shifted to the Apollo 11 mission. Stafford, Cernan and Young had done their part. Now it was time for Armstrong, Aldrin and Collins. You can see Apollo 10's 'Charlie Brown' at the Science Museum in London which is on permanent display. 'Snoopy', meanwhile, is in permanent orbit around the Sun.

DIY ASTRONOMY

Build a portable sundial

A beginner's guide to constructing your own stylish, outdoor timepiece

This month's project is a portable sundial, demonstrating the Earth's rotation with respect to the Sun. Sundial designs vary and ours is a diptych ("two fold"). This refers to the main panels, which open out to 90° like a book cover.

Sundials use a shadow to indicate the time of day. Any object such as a tree will cast a shadow on a sunny day and, as the Earth rotates, the shadow moves around a predictable curve. A simple, vertical pointer sundial works but isn't ideal, as its shadow varies over the day and between summer and winter. Most sundials use a special pointer called a gnomon that is inclined at an angle appropriate for the latitude where it is used. As the Sun moves, the gnomon projects a shadow onto a compact, calibrated dial showing the time over the year. Our design uses a thread for the gnomon, stretching from a hole in the base to one in the lid. The angle between the thread and base should match the latitude. By adding extra holes in the lid you can re-fit the thread to suit different locations where you might use your sundial. We added some horizontal slots so the appropriate latitude can be selected easily.

An accurate gnomon angle will only be achieved if the base is horizontal. To assist alignment there is a plumb bob, a balancing weight, fitted to the spare end of the gnomon thread (we used a small nut). This is suspended from a block fitted to the upper part of the open lid and if the plumb bob hangs just above a mark on the base, the dial must be horizontal.

Mark Parrish is a bespoke designer. See more of his work on his website: buttondesigns.co.uk

Making marks

At midday the Sun is due south, so any shadow will be cast northwards. This means we need to align our sundial so that its midday marking is due north. A compass fitted into the base is a way to achieve this. Six hours later, at 6pm, the Sun will be in the west, the Earth having rotated 90°. At this time the shadow will be projected at 90° clockwise from the midday position. This makes it easy to set up the markings on the dial for midday, 6pm (also 6am, which is opposite 6pm). You might divide up the resulting dial with equal spaces for the other hours of the day (7pm, 8pm, 9pm etc) but because of the geometry between the horizontal base and the gnomon, the proper spacing between hour markings becomes closer either side of midday, especially at lower latitudes. There are online dial calculators (blocklayer.com/sundial.aspx) and we have three downloadable templates for 50°, 55° and 60°N).

Although the design calls for some precision, it is easy to build and adapt. We used some timber offcuts. We'd love to see your finished and customised sundials.

More ONLINE

Download plans, diagrams and more photos for this project. See page 5 for instructions

ALL PICTURES: MARK PARRISH

Tools and materials

- Marking-out tools, including a ruler, square and pencil; a coping saw or similar; a drill and bits for screws, including a large Forstner bit to suit a compass.
- A small quantity of good-quality wood, measuring approximately 75x15x400mm-long (we used some 18mm-thick oak offcuts); a small piece of thinner wood for the sides such as 6mm-plywood or similar.
- Sundries include a small inexpensive compass, two woodscrews approximately 25mm (roundhead look nice), two small washers, a length of dark thread or fine string and a small nut or fishing weight.
- To appy a finish you'll need some oil or varnish, or suitable paint.

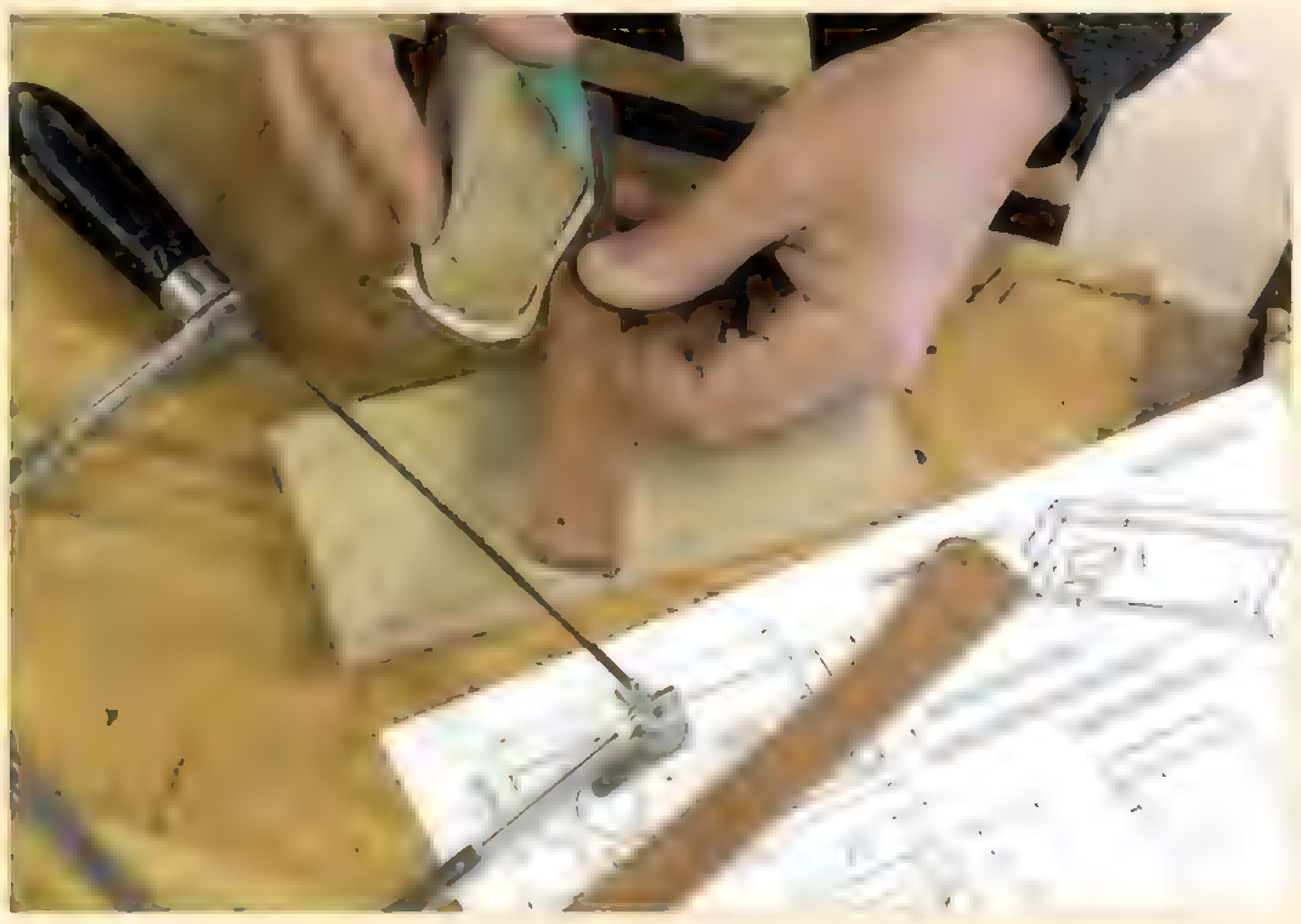
By observing the sundial's performance over the year you can make fine adjustments. Don't forget to allow for British Summer Time changes

Step by step

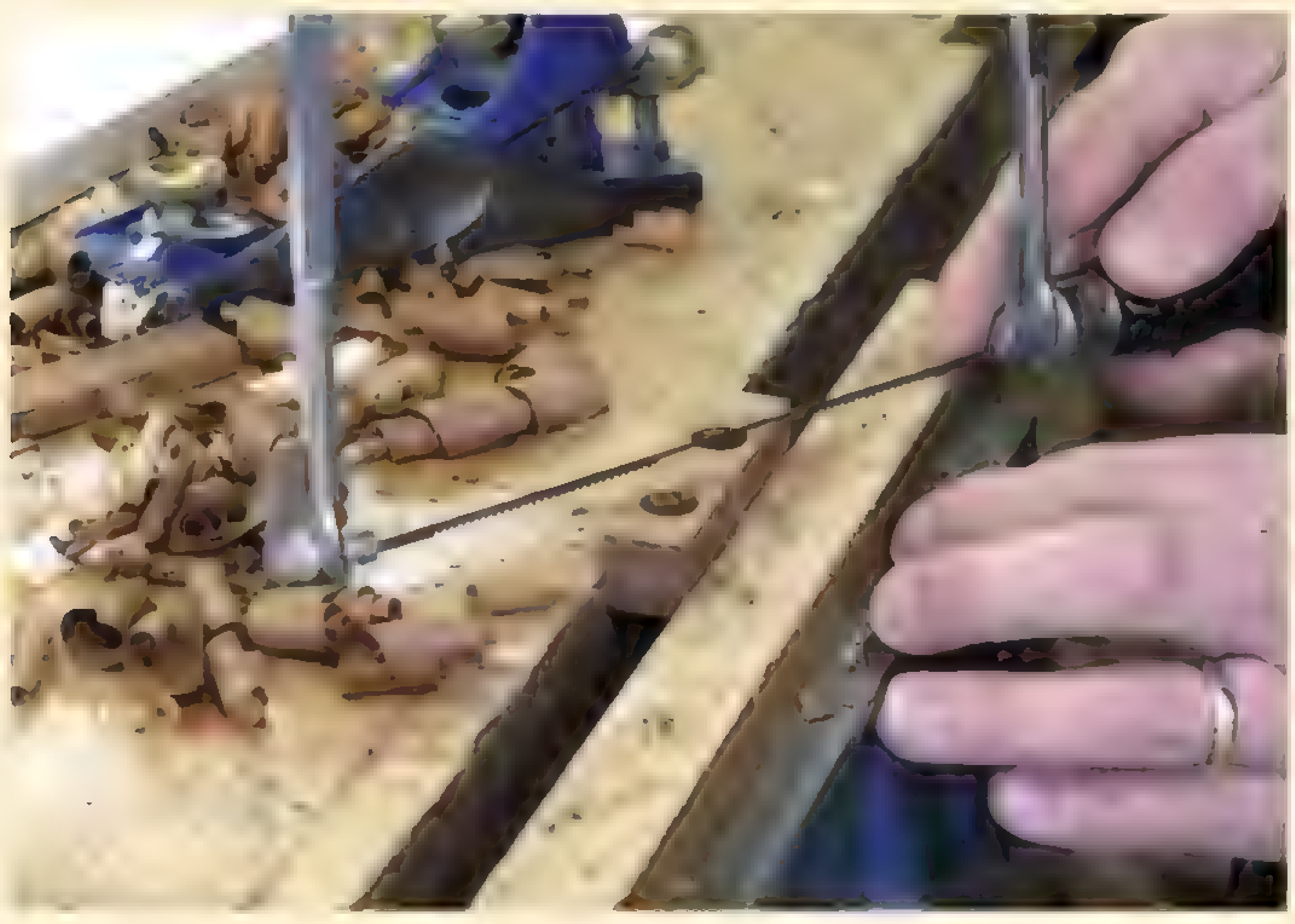
Step 1
Print out the downloadable plans and templates from the magazine website and use them to mark out and cut the main wooden parts, before sanding surfaces. Calculate the gnomon dimensions and mark the positions of the holes with a pencil.

Step 2
Use a small bit to drill the gnomon holes (about 1.5mm diameter). Take your compass apart (you just need the main part, not the body). Measure it and drill a shallow hole. Make another hole to house the plumb bob when the lid is closed.

Step 3
To enable the gnomon string to be repositioned (and aid simple threading) cut some slots from the left side to meet the gnomon holes for the latitudes you have chosen. We made one slot, which branched off to three holes to avoid too much cutting.



Step 4
Draw out the shape of the side plates, using the plans to work out the exact position of the screws forming the "hinge". We experimented with a few profiles and you could too, providing your walls don't cast a shadow across the dial in use.



Step 5
To make the block that holds the plumb line we drilled two holes in an offcut of hardwood before cutting through them to form the "spool" shape. Diagonal saw cuts in the block and top of the lid section keep the thread tidy.

Step 6
Before final assembly we used a sharp point to transfer the hour positions to our dial from the printed template for the latitude we most expected to use. We drilled shallow holes at each hour. You could add lines and numerals.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

A high-resolution image taken near the Moon's terminator highlights detail on the crater Langrenus

High-resolution lunar imaging

How to capture the fine details of the Moon's surface

The Moon is a stunning object to both observe and image. Low-resolution shots that record the whole disc or large areas are straightforward, but getting in closer for high-resolution results takes extra effort. One key skill here is the ability to assess the quality of the atmosphere passing between you and the Moon. Misjudge this and the result will look as if it has been incorrectly focused. Larger image scales can be achieved with a longer focal length, but here again assessing the correct value to match the current seeing is critical.

High-resolution imaging makes certain demands on equipment. As telescope aperture increases so does resolving power, meaning a larger scope will be able to resolve finer detail than a smaller one. This is not an issue per se, but it helps to realise that small scopes can't outperform larger ones under good conditions.

Image scale is proportional to focal length: the longer the focal length, the closer to the subject you will be able to get – up to a point. If you create an image scale that tries to deliver a higher resolution than your scope can honestly deliver, you'll end up reducing the quality of the final image for no real gain.

Assessing the correct image scale is a skill earned with experience. You can use the effective focal ratio of your telescope as a guide here. For example, aim to use an effective focal ratio of f/20–f/45 for high-resolution imaging. Effective focal ratio is the focal ratio of your scope after applying optical amplification using devices such as Powermates and Barlow lenses. So, if your scope naturally has f/8 optics, using a x2.5 optical amplifier increases its focal ratio to (2.5x8) or f/20.

Although focal ratio is a measure of light delivery speed at the camera sensor, the f/20–f/45 rule of thumb does work well. It might be tempting to aim for f/45 straight away, but this is where judgment kicks in. The effective amplification to use should be chosen to match the quality of the atmospheric seeing. If the seeing quality is poor and the Moon's surface looks blurred and distorted in real time, aim for a setup in the f/20–f/30 range. If the quality is good, aim for the f/30–f/40 range. If the seeing quality is excellent, this is the time to try the f/40–f/45 range.

Pushing your scope to its imaging limits will require its optics to be correctly aligned or collimated. This isn't complex and should be done on a regular basis. At very high image scales it's easy for a slight misalignment to deliver less than optimal results.

Make sure the instrument is visually collimated first. Then, just before you attempt to image the Moon's surface, with all optical and camera components in place, turn the scope on a mid-height, medium-brightness star. Defocus the star and examine its diffraction rings. If they show asymmetry, tweak the collimation to correct for this. Keep the defocused star in the centre of the imaging frame. It's also worth noting that this procedure can be hard to carry out in poor seeing conditions. Once this has been achieved, you're ready for the next step – capturing the image.

Recommended equipment: HFR camera, telescope, optical amplifiers, laptop, infrared pass filter

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

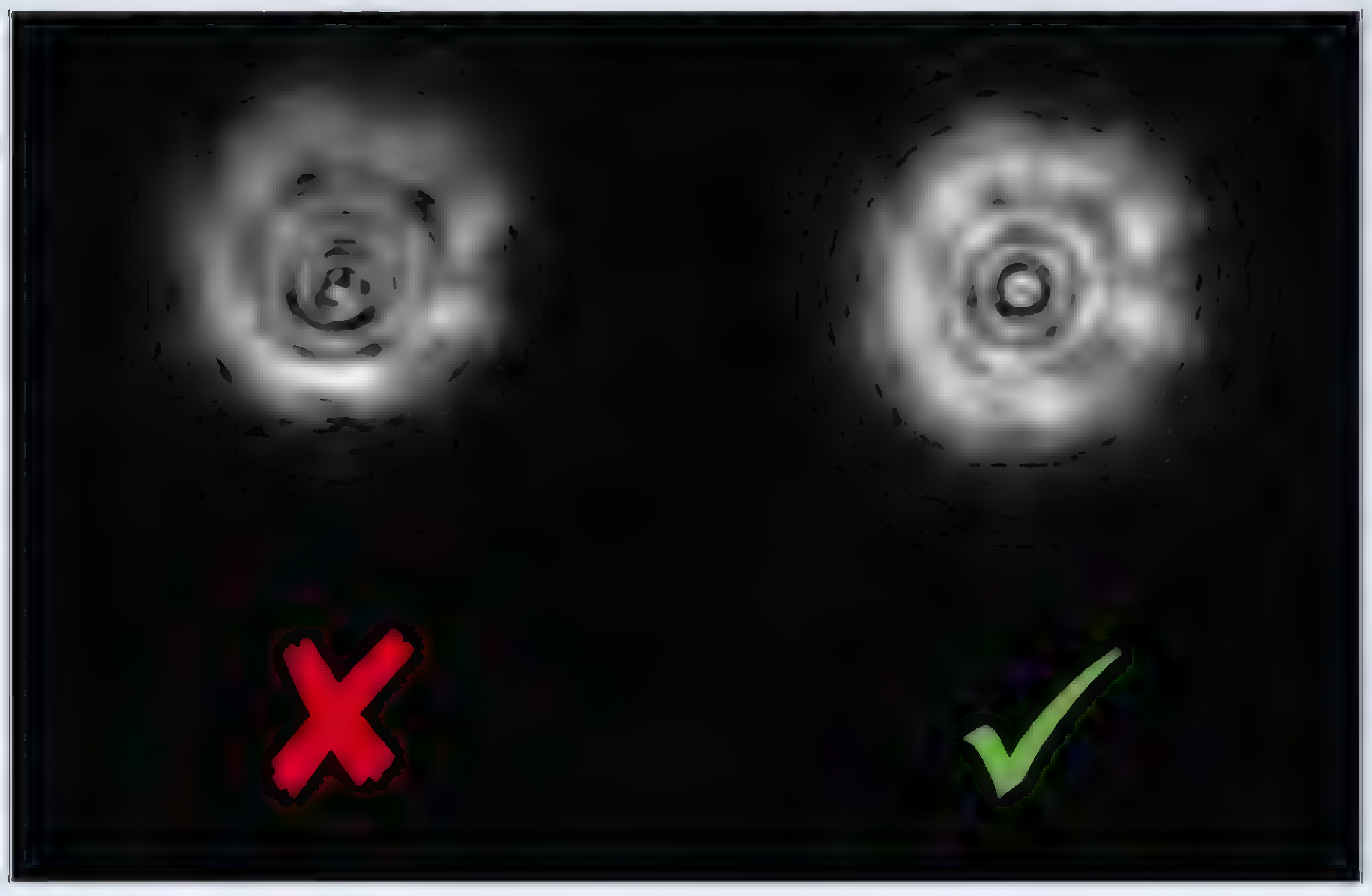
Send your images to:
gallery@skyatnightmagazine.com

STEP 1

Make an estimate as to the quality of the seeing. This assessment takes experience, but an indication is if the image looks sharp through the eyepiece or blurred and hard to focus. Shadowed features near the Moon's terminator are good for assessment purposes. If in doubt, assume poor seeing conditions.

STEP 2

Choose your target feature and work out how to get your scope's effective focal ratio in the range of f/20–f/45 using an optical amplifier such as a Barlow lens or Powermate. Fit the amplifier and bring the feature into focus. Check the finder is centered on the feature visible on the screen.



STEP 3

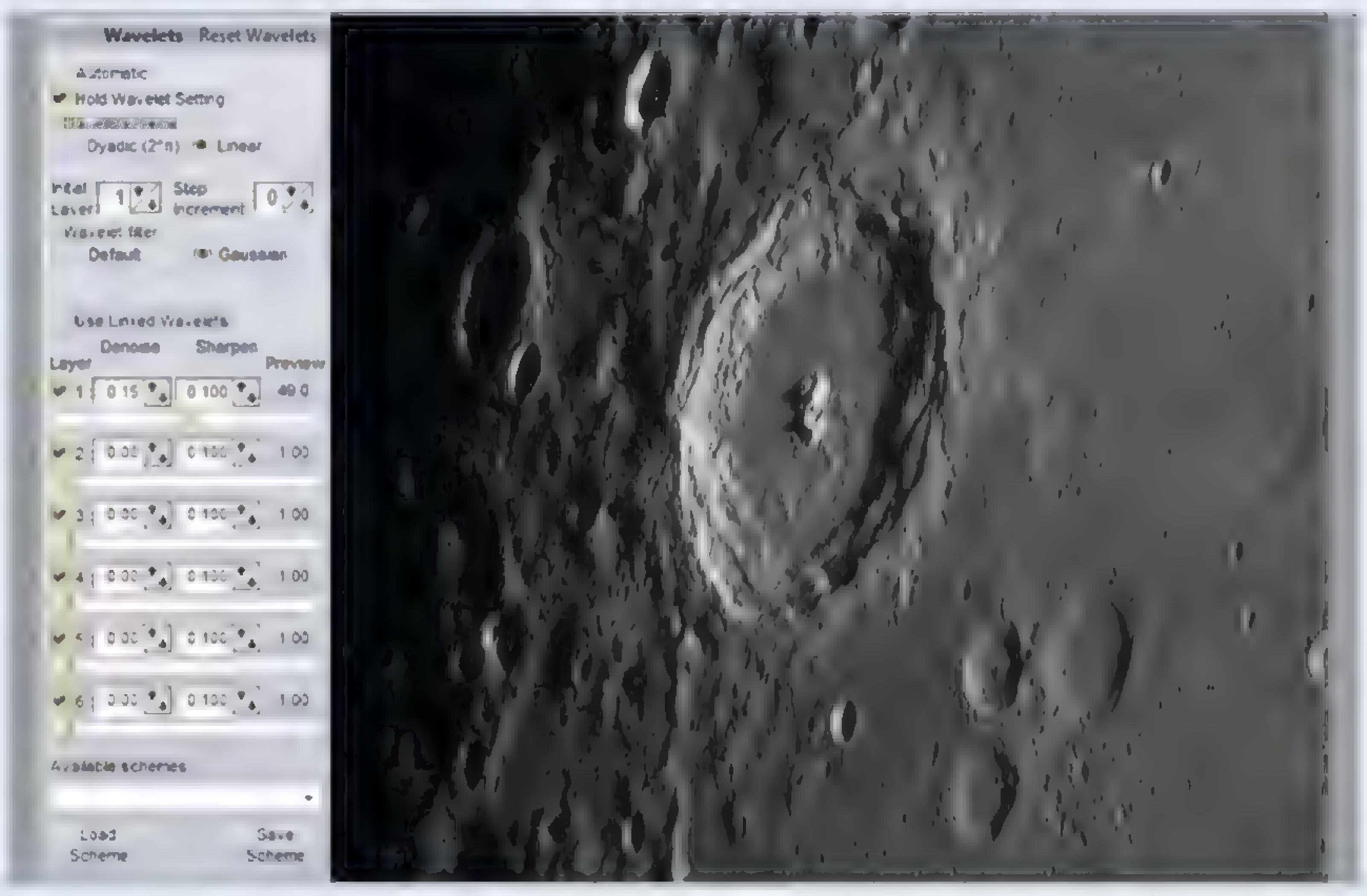
Slew your telescope to a medium-bright star half-way up the sky. Carefully defocus to reveal the star's diffraction rings. Centre the defocused star and assess how symmetrical the rings are. Consult your telescope's manual for collimation instructions and adjust until the rings appear symmetrical.

STEP 4

Slew back to your feature of choice on the Moon. One tip to improve high-resolution images is to use an infrared pass filter, because longer wavelengths are less affected by seeing. If you use one, fit it before Step 3. A filter wheel will allow you to use or discard the filter as required.

STEP 5

Make a high-resolution capture of your target feature using your favourite capture software. A strong signal – a level saturation of 70–80% – is desirable, plus a fast frame rate with the camera gain kept fairly low (below 60% if you can). Balancing the frame rate and gain is another skill that comes with experience.

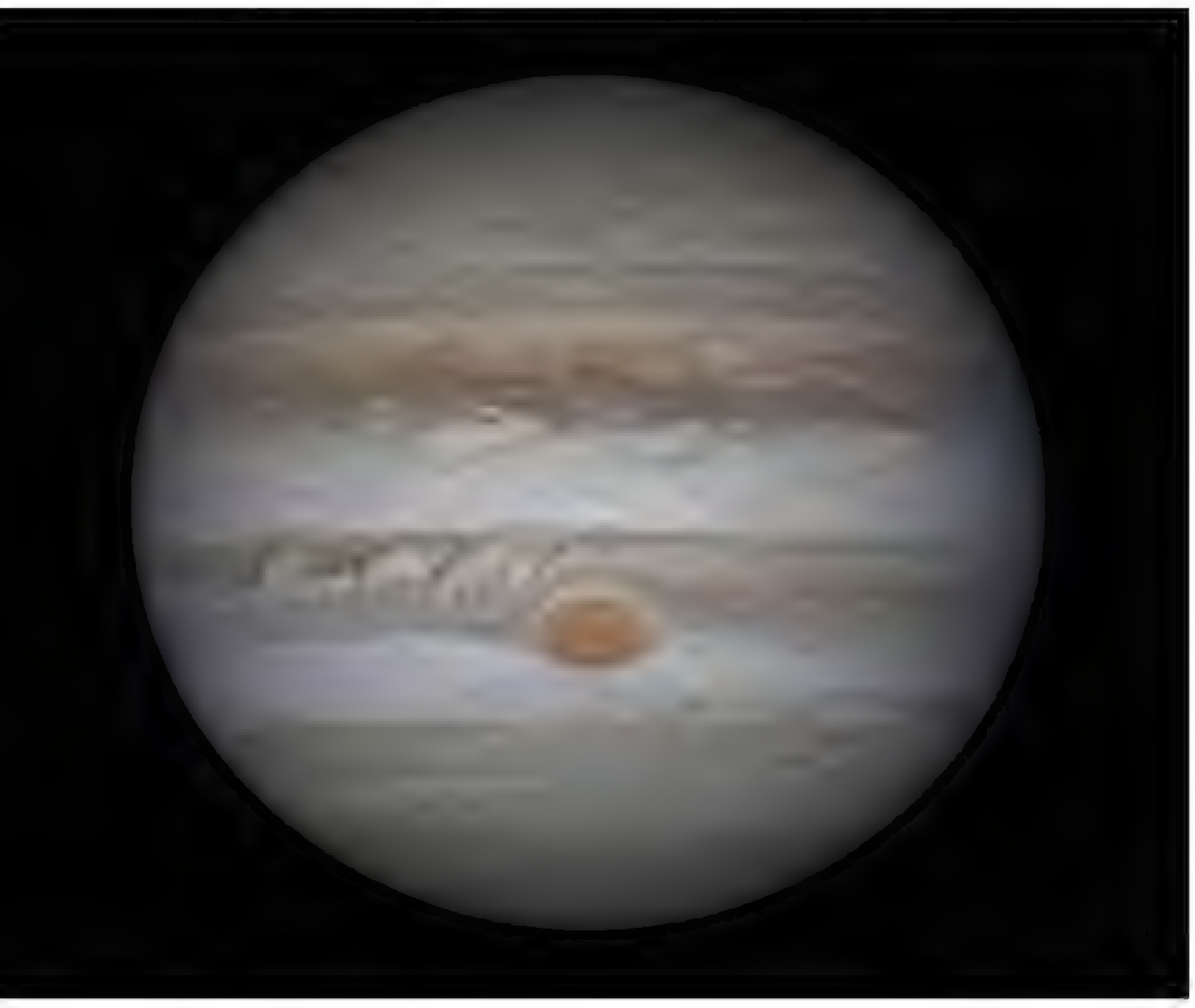


STEP 6

Aim to capture 1,000 frames. If you need to set the gain high to maintain a decent frame rate (higher than 30 frames per second), it is advisable to capture 1,000–2,000 frames. Process using AutoStakkert! (autostakkert.com) and use the wavelet function in RegiStax (astronomie.be/registax) to sharpen the result.

IIAPY Masterclass: Unravelling Jupiter

How to use images taken at different times of Jupiter's rotation to create a cylindrical map



Insight Investment **Astronomy Photographer of the Year**
Advice from a 2018 shortlisted Planets, Comets and Asteroids entrant

◀ **The processed images of Jupiter are stacked in AutoStakkert!, sharpened in RegiStax, with finishing touches added in WinJUPOS**

When it comes to planetary imaging, there is relatively little room for artistic interpretation when you are creating an image. Unlike nebulas and galaxies – which appear as dim and grey blobs to the naked eye, but as beautifully coloured in photos – the planets you see in a telescope are similar to those you often see in images. Despite this, there is still an opportunity to create an image portraying something unique about a planet.

Occasionally, planetary imagers with multiple images taken on a beautiful night or two as the target rotated, will create a map of their target. But incomplete maps often have artefacts on the edges, since pixels near the planet's limb in the original photo are stretched on the map to compensate for the planet's surface that is barely facing us, resulting in an uneven resolution. A way to deal with this problem is to replace the low-resolution edges with parts of normal images that curve away naturally, to give the map a capsule shape.

To get started, we'll need a set of multiple images, captured under excellent conditions within a few nights. The images of the planet Jupiter used here were taken on 18 and 19 March 2017 in Cibolo, Texas with a Celestron C11 EdgeHD telescope and a ZWO ASI290MM camera. We follow the typical workflow for planetary imaging: stacking the highest quality frames from videos using AutoStakkert!, sharpening those images using wavelets in a program like RegiStax, and de-rotating them in WinJUPOS to reduce graininess and to transform monochrome images into colour if necessary.

Time for a map

With our normal images finished, we're nearly ready to generate maps from them, which is also done in WinJUPOS. Incidentally, the de-rotation process makes this easier by automatically saving the images it creates with measurement files, which can be used for map generation. We generate maps using the tool under Analysis › Map computation. While there are many options to fiddle with, most of the defaults work fine for our purpose. WinJUPOS recommends a width for the maps that also matches the height with the original image. Taking advantage of this will be convenient later. While we can generate maps from

▲ **In Adobe Photoshop each map is loaded as a stack of layers. Notice how the layer masks on the right are coloured to reveal lower layers**

ALL PICTURES: ETHAN CHAPPEL

Ethan Chappel is a US-based astrophotographer who specialises in imaging planets. He was shortlisted at the IIAPY in 2018 for his 'Jupiter Unravelled' map

◄ **To give the map of Jupiter its distinctive capsule shape, two normal images of the planet are blended to both ends of the map**

▼ **To compensate for Jupiter's axial tilt, the planet's surface features need to be 'warped' by flattening the map into a single layer and moving the central region vertically**

multiple images at once here, the results would contain abrupt seams between images. Alternatively, we can generate maps one-by-one and seamlessly blend them together ourselves.

Once the maps are generated, they can be loaded into Adobe Photoshop with File › Scripts › Load Files into Stack, which loads each as a layer. Only the top map will be initially visible. We'll reveal the maps hidden underneath by adding masks to each layer. Brighter areas on a mask correspond to more opaque areas on the layer and darker areas are more transparent. Removing areas from the top map by painting the corresponding area on the mask black reveals the next map below. Repeating this process for lower maps, until the bottom layer is reached, reveals the entire area photographed between the two nights.

Sometimes there's a dark seam caused by uneven lighting as a result of the planet rotating too far between images. This can be fixed by creating a new layer on top and setting the blending mode to overlay. Carefully painting shades of grey on the new layer over the seam allows it to be hidden. The border and extra information can be hidden by selecting it with the marquee tool and colouring the area black.

With the newly merged and cleaned map, it's time to insert the unmapped images to cap both ends of the map. After opening them with File › Open and copying them over to the canvas with our maps, we hide half of each photo with layer masks and move them to align the planet's poles with the top edges of the map.

The perimeter should line up nicely, but surface features are likely to be misaligned due to Jupiter's slight axial tilt, which is present in the normal photos but removed from the maps. To correct this, we need to adjust the map in such a way that preserves the perimeter while warping the area. We can achieve this by flattening the map into a single layer and warping it with Edit › Transform › Warp and moving the central region of the map vertically. Patience with this final step is crucial, as warping an area of the map to align it with one end can misalign it from the other.

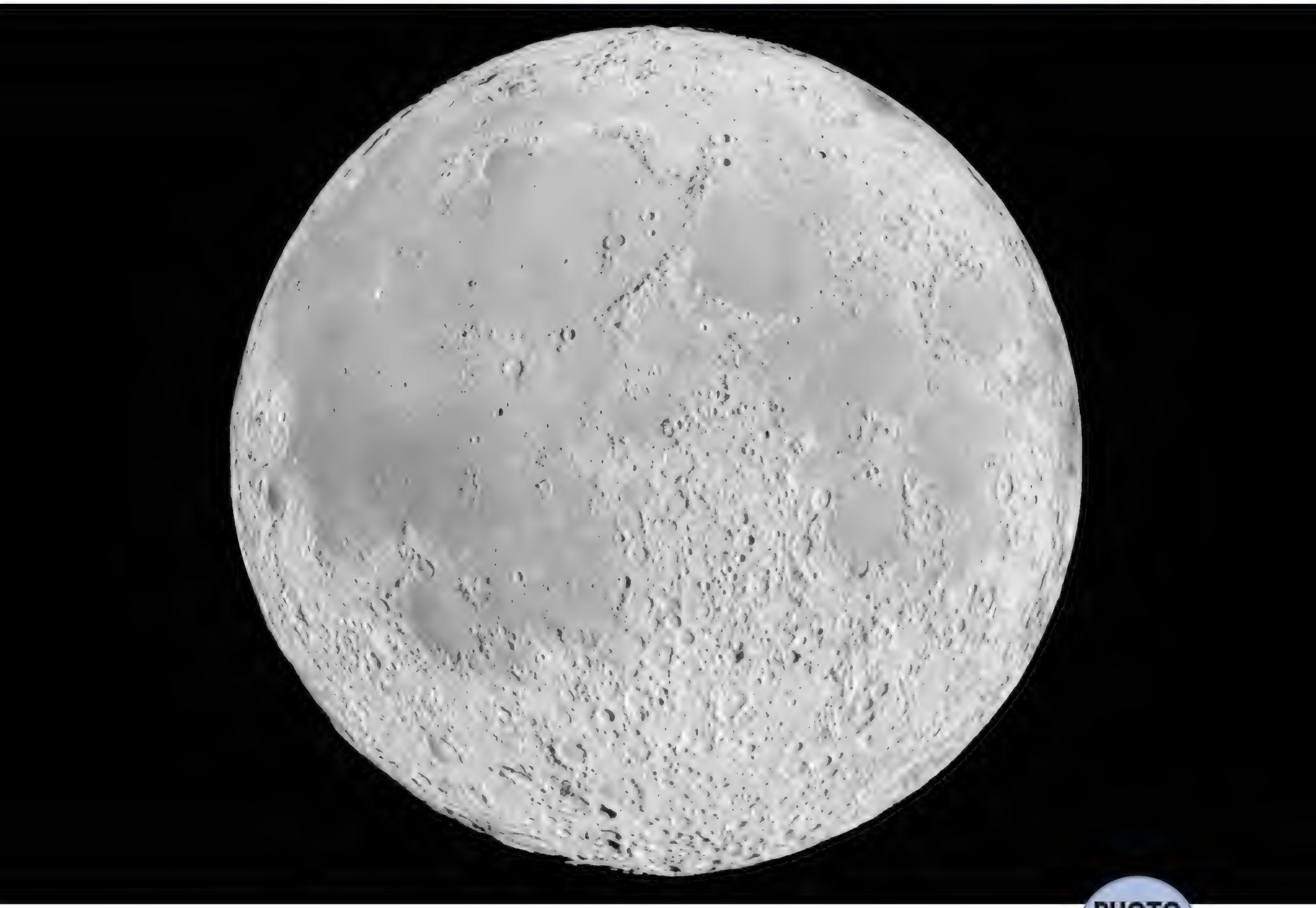
Once everything is nicely lined up, our capsule-shaped map is complete. It can help to add a new layer with overlay blending, to make subtle brightness corrections with shades of grey for the final result if needed.

▼ **The final capsule-shaped map of Jupiter is complete, with subtle corrections to brightness**

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More ONLINE
A gallery containing these and more of your images



△ Shadow Moon

PHOTO OF THE MONTH

Ken Florey, West Sussex, 2007–18

Ken says: "You never lose that feeling of first seeing a crescent Moon filling an eyepiece. I wanted to capture this magic in a 'Full Moon' with detail all over. This sight is not available in nature as it requires imaging the shadows progressing during the waxing cycle. Weather and libration made this a decade-long labour of love."

Equipment: Fuji FinePix bridge 6MP and 12MP cameras, Sky-Watcher 150mm f/8 refractor, Sky-Watcher HEQ5 Pro equatorial mount, 50mm Praktica DSLR lens (as eyepiece).
Exposure: ISO 400, multiple 0.05" and 0.025"
Software: Micrografx Picture Publisher

Ken's top tips: "The Moon returns frequently and is bright, allowing short exposures, so take single shots of different exposures and pick the best. The brightness range is often too great resulting in a blackened terminator, so narrow the framing and be prepared to combine different exposures in a mosaic. Overcome libration distortion by stretch-fitting each panel over a single full Moon base shot and work in a high DPI resolution, saving in a lossless format (.tif) and backing up."

The Bubble Nebula ▷

Martin Bradley, Chesterfield, 29 August – 10 October 2018

Martin says: "I wanted to capture the fine detail on the bubble and ended up with nearly 30 hours of data. I was pleased with its appearance and ionisation fronts."

Equipment: QSI 532wg mono CCD camera, Sky-Watcher Explorer 190MN Maksutov-Newtonian, Mesu Mount 200. **Exposure:** 34x1800' Ha, 21x1200' OIII, 16x1200' SII. **Software:** MaximDL, CCDstack, PixInsight, Photoshop

◁ Horsehead and Flame Nebulae

Chris Kitson, Birmingham, 5 February 2019

Chris says: "Weather conditions were a little challenging due to the clouds, but I love how the wall of nebulosity pops behind the Horsehead, and the structure in the Flame Nebula is amazing. I'm looking forward to imaging this again when I have a dedicated astronomy camera."

Equipment: Canon EOS 600D DSLR camera, William Optics Zenithstar 103 apo refractor, Sky-Watcher EQ6-R Pro SynScan mount **Exposure:** 20x300" Ha, 35x300" RGB **Software:** DeepSkyStacker, PixInsight, Lightroom

SpaceX launch

William Brown, California, US
7 October 2018

William says: "I went to see the SpaceX Falcon 9 launch last October from Vandenberg Air Force Base. I was not expecting much from 175 miles away but I set up my camera in case there was something worth taking a photo of. When I opened the files I was excited to see what I had captured."

Equipment: Nikon D7500 DSLR camera, Nikkor 10-24 f/3.5-4.5 ED AF-S DX lens **Exposure:** 6" **Software:** Photoshop

△ The Andromeda Galaxy

Gerard Tartalo Montardit, New Mexico, US, October 2017

Gerard says: "The monochromatic data is much finer and better than my colour camera. Perhaps the biggest challenge has been to correctly conjugate the three RGB (red green and blue) channels and then add it to the luminance to be processed later."

Equipment: SBIG STX 16803 CCD camera, Astro-Physics 305mm f/3.8 astrograph, Astro-Physics 1600 GTO mount **Exposure:** L 50x300", R 33x300", G 44x300", B 21x300" **Software:** DeepSkyStacker, Fitswork, FastStone, GIMP

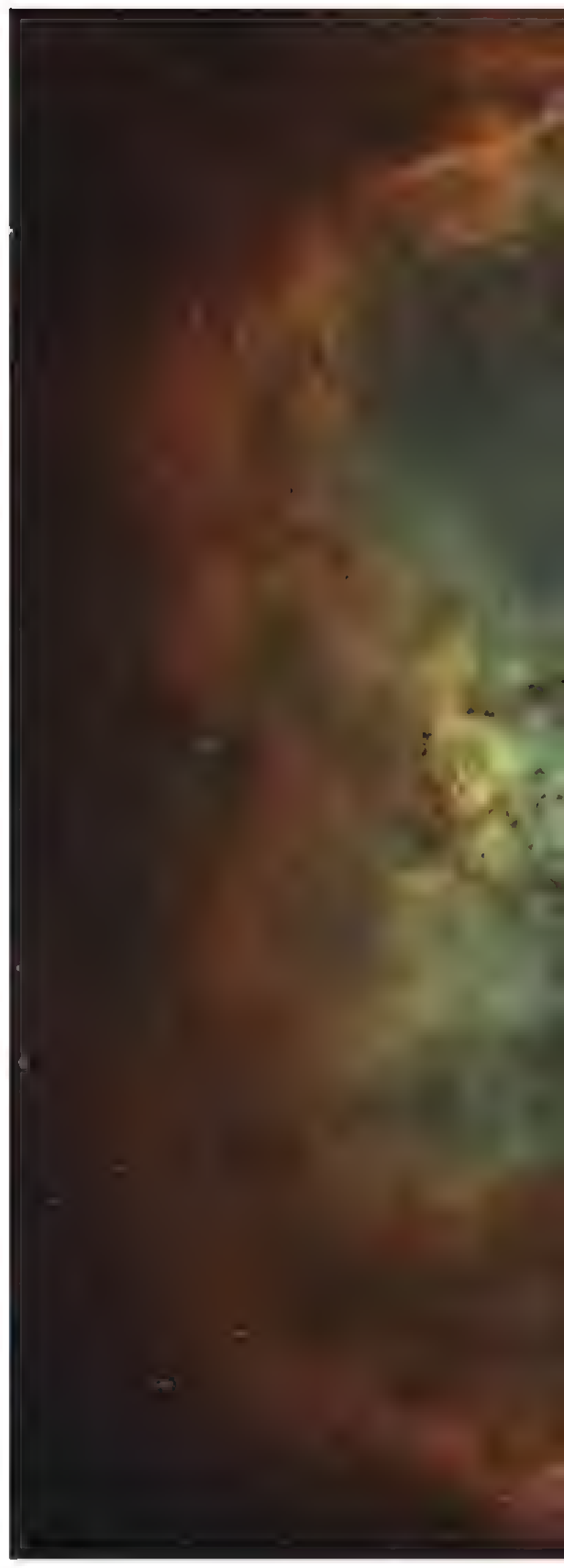
The Rosette Nebula ▷

Steve Bishop, Wakefield, 27 February 2019

Steve says: "Looking at other people's attempts, I like how strong the different narrowband wavelengths are and the colours you can create from them. I only started astrophotography last year and have waited a long time for the nebula to appear in my limited views of the night sky."

Equipment: Altair Hypercam 183M Pro mono camera, PrimaLuceLab Airy black 80T apo refractor, Sky-Watcher NEQ6 Pro SynScan mount

Exposure: 12x10' each Ha, OIII, SII; 10 darks, 20 flats. **Software:** Astrophotography Tool, PHD2, DeepSkyStacker, Photoshop



The Milky Way ▷

Anvar Ghadery, West Azerbaijan, Iran, 24 April 2018

Anvar says: "This is a river on the Iranian border with Iraq; a river that simply crosses the border of two countries. And beyond the border lies the Milky Way."

Equipment: Canon EOS 6D DSLR camera, 20mm Sigma lens **Exposure:** ISO 4000 f/2, 15"

△ Rising Moon

Andrew Allan, Perth and Kinross, 30 April 2018

Andrew says: "I had to wait for the right time of year to get clear skies and for the Moon to align with the treetops. I also needed to time it perfectly due to the Moon moving across the sky quickly when zoomed in."

Equipment: Canon EOS 1300D DSLR camera, Celestron Astro Fi 102 Maksutov Cassegrain. Exposure: ISO 400, 0.025" Software: Snapseed

Smartphone startrails

Jeff Dai, Xin Jiang, China, 13 September 2018

Jeff says: "With the fast development of phone technology, I wanted to capture star trails on my smartphone. The image shows the graceful trails of the southern stars as Earth rotates on its axis. Moonlight illuminates the snow-capped mountains of the Xiate Ancient Trail."

Equipment: MEIZU 16 smartphone, tripod
Exposure: ISO 3200 f/1.8, 75x20"
Software: StarStaX, Photoshop

◁ The Seagull Nebula

Terry Hancock, Tom Masterson, Grand Mesa Observatory, Colorado, US, 1 February 2019

Terry says: "The nebula was in a very good position to shoot for most of the evening, starting at 7:15pm one hour after twilight in the east and finishing at 01:15am at an elevation of 31° in the west for a total acquisition time of six hours."

Equipment: QHY128C CMOS camera, Takahashi Epsilon-180ED f/2.8 astrograph,
Exposure: 36x 600" colour
Software: Maxim DL6, PixInsight, Photoshop

◁ M106

Mark Shelton, Marston Green, 25–28 February 2019

Mark says: "I chose the target as a test for my new camera, as it was high in the sky and a worthy first light. Any new camera needs tweaks to get it right and this image proves it is pretty much spot on."

Equipment: Moravian G3 16200 CCD camera, Celestron C14 Schmidt-Cassegrain, Paramount MX+ mount.
Exposure: 22x10' RGB, 35x15' L
Software: PixInsight, Photoshop

Taurus and Auriga border ▷

Nikola Milicev, Horgoš, Serbia, 1 January 2019

Nikola says: "When I aimed my camera at the Pleiades I knew I could frame the California Nebula too, although my main target was the dust between Taurus and Auriga. As it was cold, my lens temperature dropped and dew formed on the front glass, which ended my session early."

Equipment: Canon EOS 1300D DSLR camera, Canon EF 50mm f/4 lens, Sky-Watcher Star Adventurer
Exposure: ISO 1600, 26x5'
Software: PixInsight, Photoshop

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We've teamed up with Altair Astro UK to offer the winner of next month's *Gallery* an Altair Astro Planet-Killer 685nm Premium IR Pass Filter with AR coating, designed to deliver sharper lunar and planetary images with mono CCD or CMOS cameras. For more info visit: www.altairastro.com • 01263 731505

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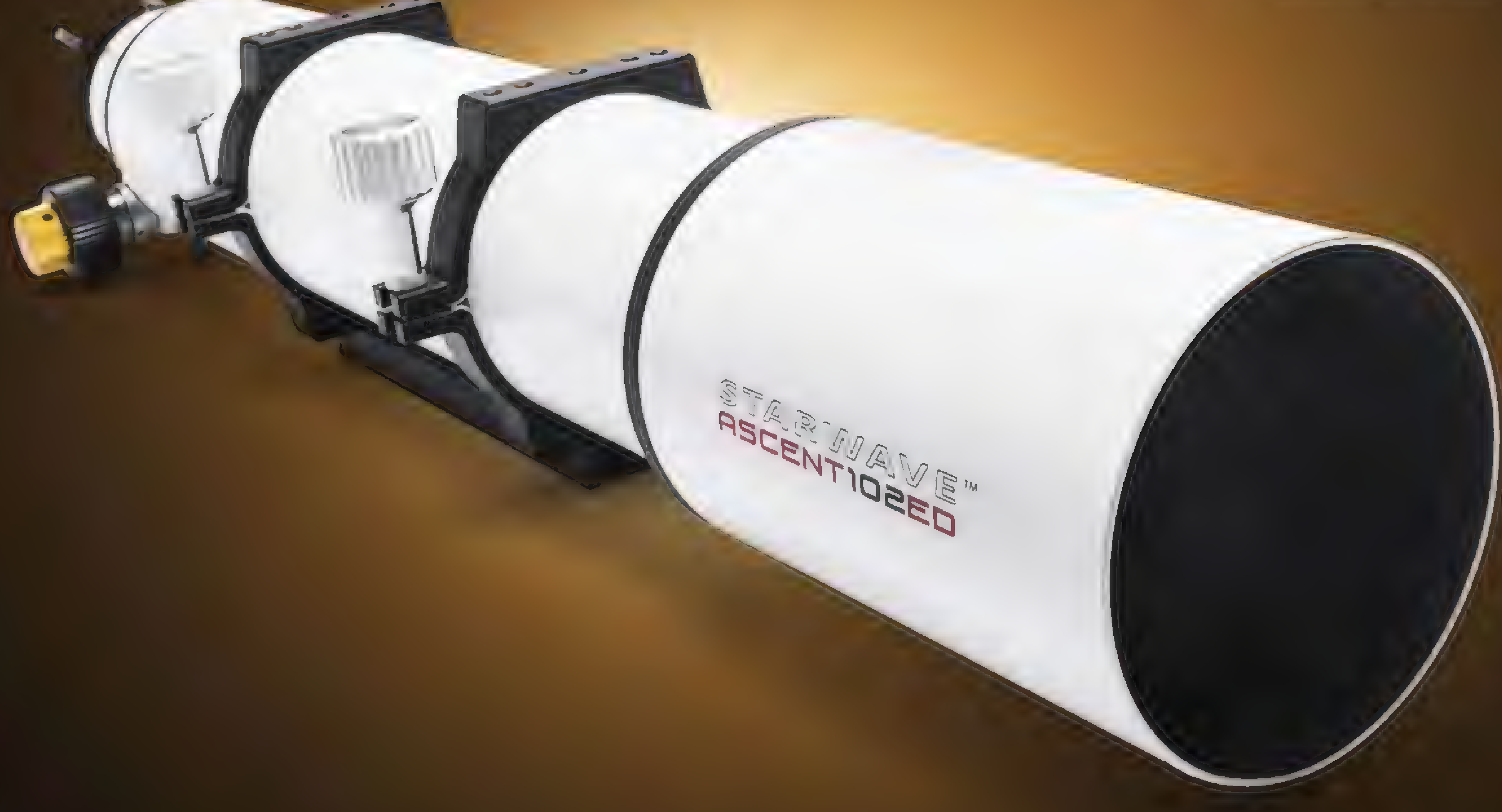
86
Discover how the lightweight Altair Starwave ASCENT 102ED F7 refractor performed



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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Altair Starwave ASCENT 102ED F7 refractor telescope

An easy to use dual-purpose telescope with a lightweight frame

WORDS: PAUL MONEY

VITAL STATS

- **Price** £549
- **Optics** Fully multi-coated ED doublet lens in collimatable cell
- **Aperture** 102mm
- **Focal length** 714mm; f/7
- **Mount** Tube rings with Vixen dovetail bar
- **Focuser** 10:1 fine focus 2.5-inch focuser, with 93mm of travel
- **Weight** 4Kg
- **Extras** Removable dew shield; 2-inch to 1.25-inch adaptor; front and back dust caps
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.** altairastro.com

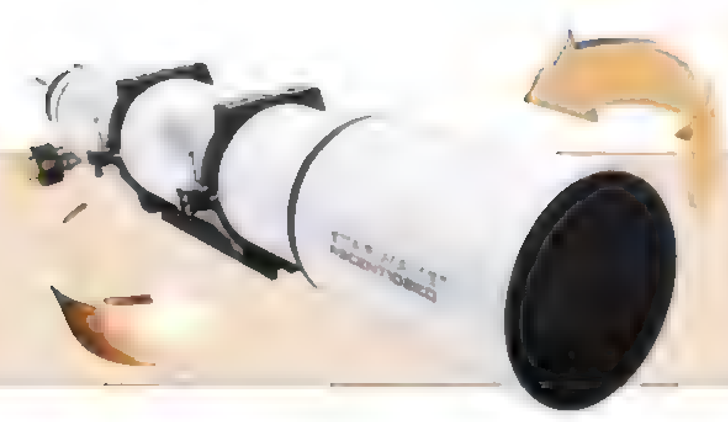
Refractors are probably the most often used and sought-after type of telescope, as they are simple to set up and have no mirrors to collimate. They also have a variety of focal lengths to suit your astronomical needs, be it visual or imaging. The latest offering from Altair Astro is the Starwave Ascent 102ED, which is available as either an f11 long focus version or the f7 short focus variant we review here.

Looking smart in powdered white with a black finish focuser, the refractor comes as a basic tube with tube rings and a Vixen-style mounting bar, removeable dewshield, 10:1 fine focuser and 1.25- to 2-inch adaptor. The front objective lens is a doublet configuration, made from ED (extra dispersion) glass and all the surfaces are multi-coated for a crisper view – especially useful for planetary and lunar observation. The 102mm aperture provides 63 per cent more light-gathering power than an 80mm objective (front lens) which helps to give brighter deep-sky views too.

Hunting for stars

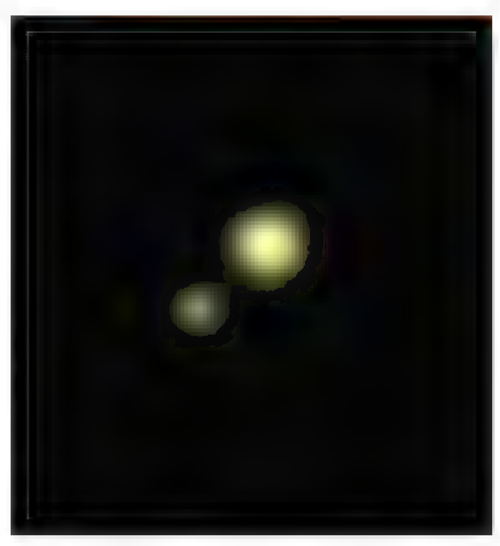
For our visual tests we mounted the scope on our Sky-Watcher AZ-EQ6 in EQ mode, added our dielectric star diagonal and used our 2-inch and 1.25-inch eyepieces to give a good range of magnification. In our first clear night the Moon was high in the sky, but that didn't stop us testing the quality of the field of view by using the star Procyon in Canis Minor. For this we used our 2-inch, 21mm Tele Vue Ethos eyepiece and enjoyed a spectacular view as we moved Procyon from one side to the other in the eyepiece. We enjoyed a crisp view of the star, across 90 per cent of the field of view, before slight distortion began to show. Next, we took a tour of a variety of coloured stars – including Capella, Betelgeuse, Pollux and Aldebaran – to assess the colour rendition and we were pleased with the Ascent 102ED's crisp views and colour.

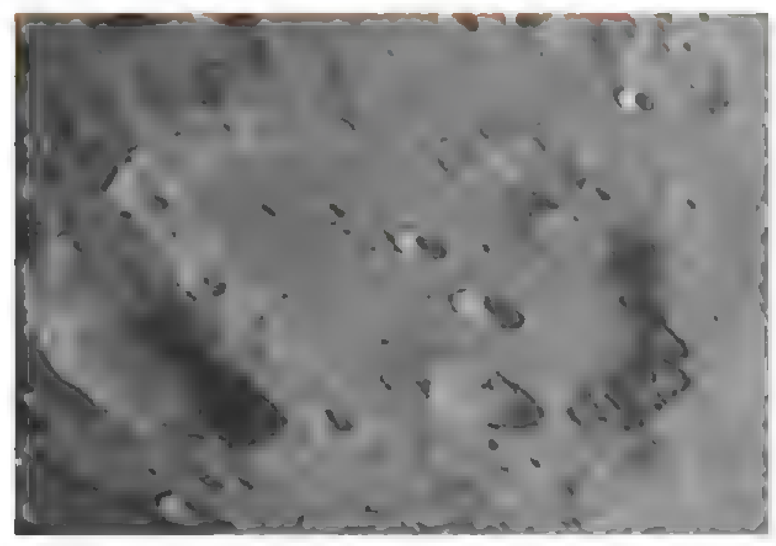
The Moon was sharp and full of detail with no sign of chromatic aberration (blurring with coloured edges) on the bright edge of the limb. Chromatic aberration happens when colours don't all come to the same ►



See an interactive 360° model of this scope at **www.skyatnightmagazine.com/AltairAscent**

Easy on the eye





▲ From left: A stacked image of star Algieba and crater Clavius taken with the GPCAM2 290C and 2x Barlow lens

The lightweight body of the scope made it easy to set up on our chosen mount, whether we were viewing or imaging. The quality of the views impressed us as we could add in higher magnification eyepieces and still get rewarding vistas, be it with the Moon or galaxies. To test the resolving power, we viewed the double stars of Algieba and Castor with our 9mm eyepiece, easily splitting them into their component stars with good colour contrast, especially Algieba. Adding in the x2 Barlow lens and our Altair GPCAM2 290C camera we achieved our best images of both pairs with a clean, clear space between the stars.

The Moon has lots of fine detail, so we used the same camera combination to close in the crater Clavius. We were rewarded when we stacked 1,500 frames out of over 5,000, to get a crisp view of the small craters inside it. The higher magnification views of galaxy M82 also picked out the darker breaks in its disk, all making it an enjoyable viewing experience.

Body

The tube is machined aluminium, 73cm long and weighing just 4kg, making it lightweight and easy to use. It cools down quickly, enabling you to be up and viewing or imaging quickly, which is helpful for taking advantage of those occasional clear patches of sky.

Optics

The front objective lens element sits in a collimatable cell. It's a doublet lens with multi-coatings on all its optical surfaces, allowing for good control of colour correction. The lens is 102mm in diameter with a focal length of 714mm, giving a focal ratio of f/7. It's ideal for visual and imaging purposes.

Tube rings

The two tube rings gave firm grip yet could be loosened to rotate the tube if needed for a better imaging orientation. They have M6 mounting holes for attaching additional equipment such as a guide scope, while attachment to a mount is via the Vixen dovetail bar.

Focuser

The focuser is a smooth, dual-speed, non-slip 2.5-inch geared unit with 93mm of travel and a tension adjustment screw underneath. The tension screw allows for heavy equipment such as large cameras to be attached and locked off, so the focus doesn't slip during imaging.

Dew shield

The metal dewshield is 200cm in length and 12cm in diameter, and can be unscrewed for lens cleaning. Its internal surface is a matt black, cutting down on extraneous light and it worked well under damp conditions, allowing time for viewing and imaging before the lens showed signs of dew.

KIT TO ADD

1. Altair 0.8x reducer

2. Altair 2-inch star diagonal

3. Altair 18mm ULTRAFLAT eyepiece

▸ focus, so we were pleased to see it well controlled. After a thrilling tour across the lunar landscape with our 26mm eyepiece, we added our 2x Barlow lens to view more detail. During moments when seeing conditions were good, the floor of the crater Plato was revealed as smooth, but with indications of small craters popping into view. Our Canon EOS 50D DSLR captured a nice view of the Moon, but it was a little on the small side at f/7. Swapping to our Altair Astro GPCAM2 290c colour camera, we captured several videos of the southern and northern hemispheres of the lunar landscape to produce crisp detailed images of the area covering Clavius and Tycho. The focuser held our various imaging cameras with no slippage and we were able to test plenty of accessories. Sadly, the best planets – Jupiter and Saturn – were too low along the ecliptic for us to view, but we did manage to see Mars, despite its small disk, and there was a polar cap and some subtle surface markings for us to enjoy.

We had to wait almost to the end of our review period for a night with no Moon and one of the clearest, darkest skies we've had recently for a deep-sky appraisal. Again, we took a visual tour of the night sky's main delights, taking in wide-field views of the Sword of Orion, using the Tele Vue Ethos 21mm eyepiece, with lots of nebulosity on show in the Orion Nebula. The Pleiades star cluster, M45, sparkled like diamonds on black velvet, with the Merope Nebula just viewable with averted vision. The Andromeda Galaxy, M31, was a little low down but we could see the faint disk stretching across a large part of the almost 3° wide field of view and the companion galaxies were prominent.

Adding the DSLR camera we took images of the Sword of Orion and the Leo Triplet of galaxies. They showed reasonable colour correction, since imaging is always more demanding compared with visual, although we did note a little blurry chromatic aberration. Overall, however, the Ascent 102ED f/7 performed well and would make an excellent addition to your equipment collection.

VERDICT

Build and design	★★★★★
Ease of use	★★★★★
Features	★★★★
Imaging quality	★★★★
Optics	★★★★
OVERALL	★★★★½

▲ A southern lunar landscape captured with the Ascent 102ED f/7 scope and a GPCAM2 290C camera. The stack has 2,000 frames

▲ The Leo Triplet of galaxies captured with the Ascent, 102, f/7 scope and an 0.8x focal reducer. The image is a stack of 21 frames, each 60-second exposures at ISO 800

◂ A vivid view of the Sword of Orion captured with the Ascent 102 f/7 scope and a 0.8x focal reducer. The image is a stack of 13 frames, each 60-second exposures at ISO 400

ZWO ASIair smart Wi-Fi

ASI120MM Mini camera and 30F4 Mini guidescope

An auto-guiding bundle that makes astrophotography simpler and easier to control

WORDS: TIM JARDINE

VITAL STATS

- **Price** £381
- **Guidescope** 30mm objective lens; 120mm focal length; 1.25-inch fitting
- **Guide camera** USB2.0 CMOS camera, 1/3-inch-sensor, 1280x960 resolution
- **Main unit** ZWO ASIair Smart Wi-Fi unit, including SkySafari bridge with ASI USB3.0 camera control
- **Weight** 500g
- **Extras** Hook and loop mounting pads, SD card reader, USB-RS232 cable, short USB cable
- **Supplier** 365 Astronomy

When Raspberry Pi devices appeared, we were excited by their potential to simplify astrophotography and the ZWO ASIair has been developed to do just that. The package we are reviewing is a 'bundle' that includes a 30F4 mini guide scope and ASI120 guide camera.

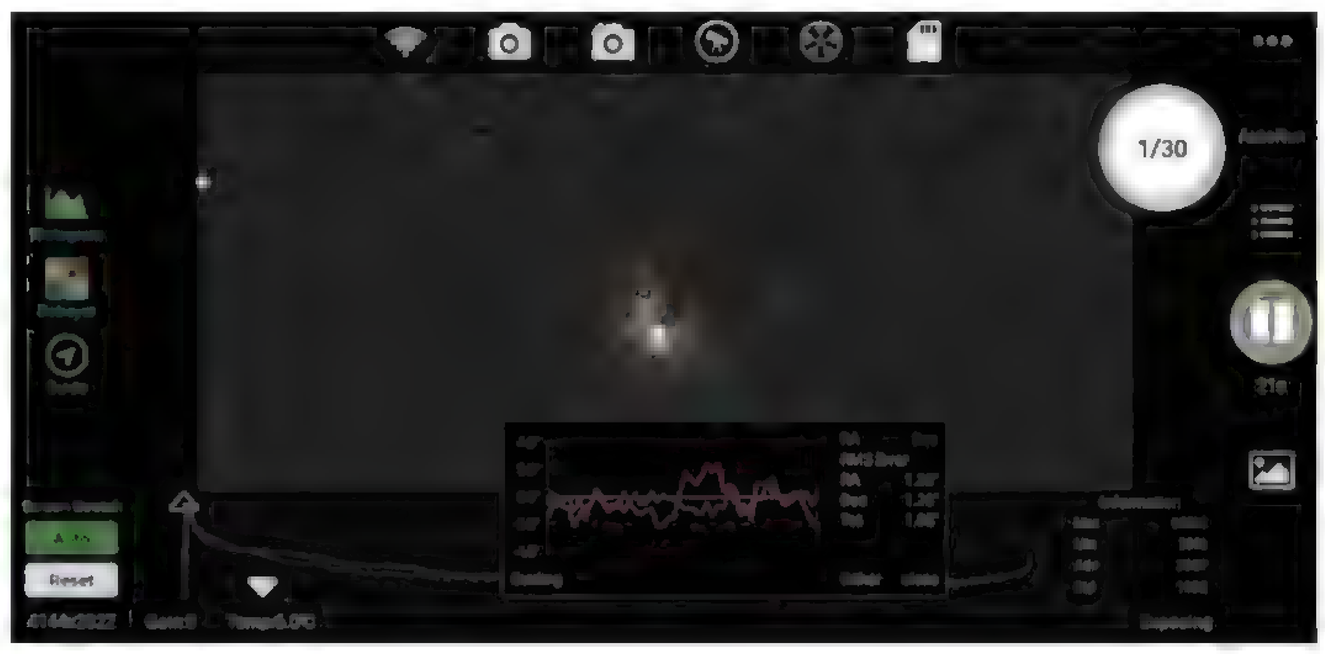
The ASIair is lightweight and compact, and designed to be fitted on or near to your telescope with hook and loop pads. With so many useful features it is difficult to accurately describe its functions in just a few words, but basically it is a stand-alone computer that can control ZWO cameras and a filter wheel, provide Wi-Fi connectivity to a mount, and auto-guiding. A 12V DC supply is required to power the ASIair's 5V converter and, once turned on, the ASIair establishes its own local Wi-Fi, either 5G for faster communication or 2.4G for greater range. Smartphone or tablet users can then connect directly to the ASIair via the downloadable ZWO ASIair app.

Best of all worlds

The unit is compatible with most popular telescopic mounts, including Celestron and Sky-Watcher. These can in turn be controlled using a smartphone or tablet, thanks to integration with SkySafari, a popular planetarium app. We connected our 10 Micron mount with the supplied RS232 cable, and within a few moments were able to simply tap on targets within the SkySafari app and the mount happily slewed to them. Typical mount handsets can be clunky to use and require repeated button pressing and menu navigation, not to mention the trailing cables. They always seem to end up snagging on something, so the ability to stand back from the mount and simply click your next target on a phone screen is probably reason enough to invest in an ASIair unit. But it is capable of much more, as we discovered. ▸

See an interactive 360° model of this bundle at **www.skyatnightmagazine.com/ZWOASIair**

WWW.THESECRETSTUDIO.NET X 4, TIM JARDINE, ZWO



Smooth operator

Not only is the ASIair unit itself nicely made, the app that controls it is slick, well designed, and simple to use. Astronomy software can become complicated and having to navigate overly technical applications in the dark with cold hands is fairly daunting.

This app is a pleasure to use and provides almost everything you need to know on one screen, including image progress, guiding graph and image preview. There's a histogram stretch, to give an idea of how much faint signal the camera is collecting. Colour images can also be debayered – where colour filters are adjusted – while you are on the move.

The ASIair app runs on recent Android and iOS devices. When tested, it ran smoothly on a recent smartphone and an older Android tablet. It would have been nice to see a night vision mode with red controls. The ASIair could be used at public astronomy events, displaying the object the scope is trained on easily for all to see on a screen, without hindrance of cables.

30F4 Mini guidescope

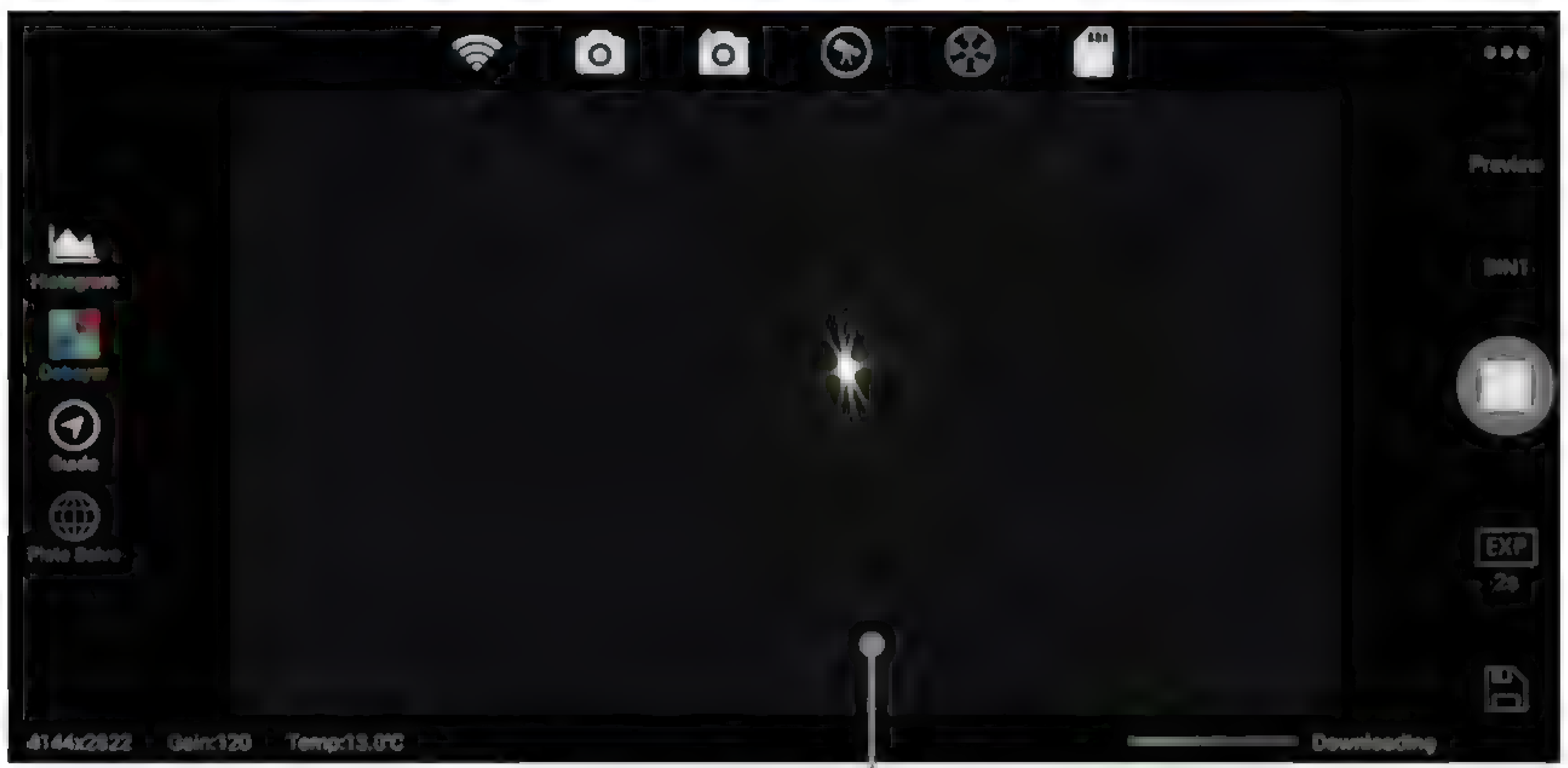
Mounted on a standard finder-scope shoe, this 30mm, f/4 scope has a helical focusing method with 20mm of travel. Lightweight and extremely compact, it nonetheless provides a clear, wide image of the sky for plenty of guide star options without adding too much weight. There are two thumbscrews for holding a 1.25-inch camera.

ASIair unit

The lightweight ASIair unit provides four USB2.0 ports, ethernet connection, and an SD memory card slot, with a 32GB SD card included. It is powered by the supplied 5V USB lead, using a 12V DC power source (not supplied) and establishes a local 5G or 2.4G Wi-Fi within seconds of being switched on.

ASI120MM mini camera

Nicely matched to the guidescope, the monochrome ASI120MM Mini camera has 1280X960 resolution, with a 12-bit ADC (analogue to digital converter) and can be used as a planetary or lunar camera in its own right. As a guide camera we found it to be amply sensitive using a medium gain setting, with images demonstrating low read noise.



Focus assistant

Accurately focused images are essential for good quality results. Within the ASIair app there is a focusing assistant tool which allows coarse and fine adjustments and displays the results as a numerical value. Alternatively, the live view star image displayed on a phone or tablet works well with Bahtinov mask focusing, a diffraction-based technique.

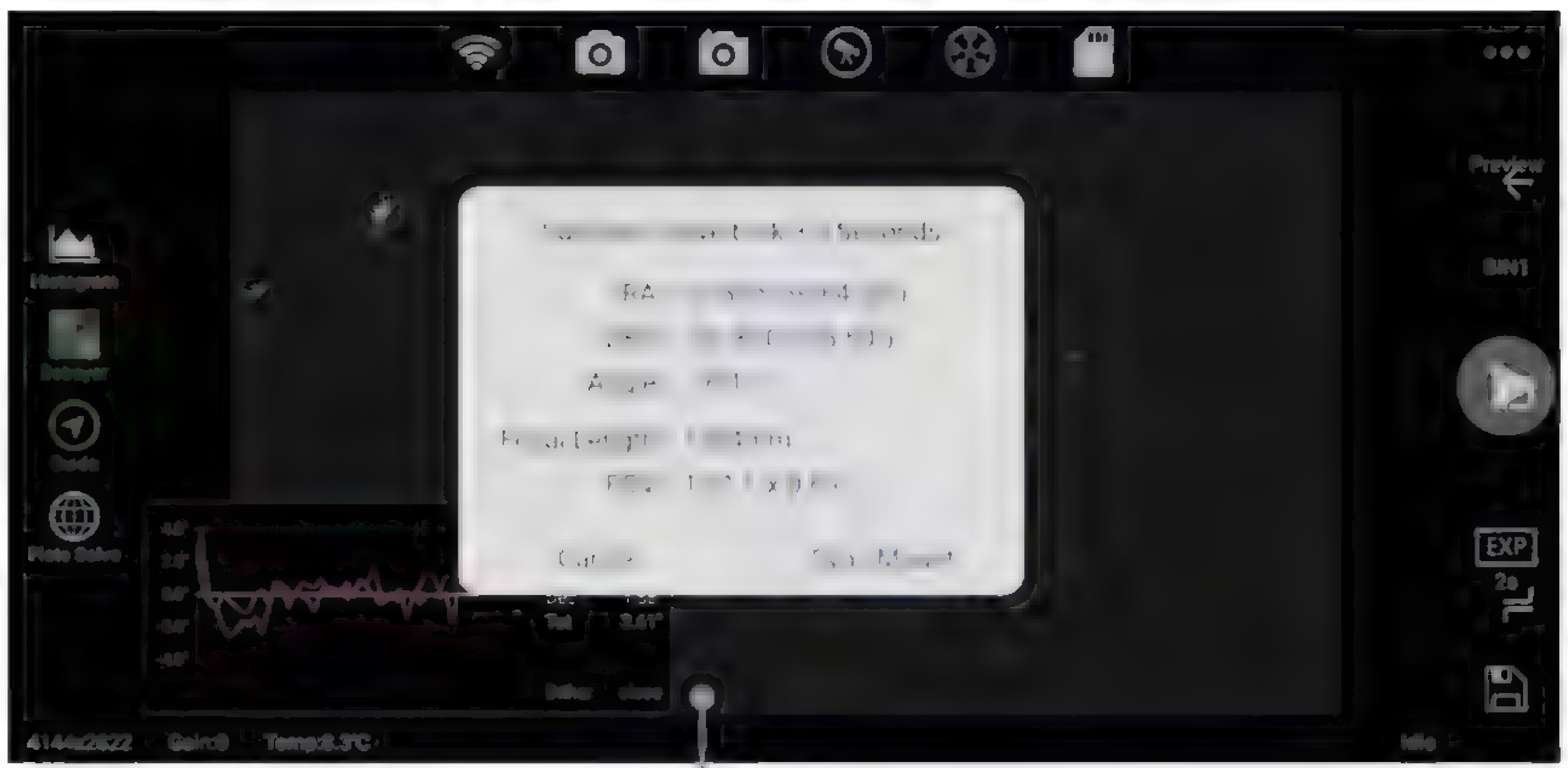


Plate solving

The off-line plate solving function works by comparing an image of the sky taken by the camera against a database, and accurately identifying the mount's position. After syncing the mount accordingly, the Go-To positioning accuracy of the mount will be improved, allowing targets to be located more effectively.

▸ All ZWO USB3.0 cameras, cooled cameras and ASI mini cameras are recognised by the ASIair. Our supplier kindly made an ASI294MC camera available to test the imaging capability of the system. Before starting the imaging run though we set up the 30F4 guidescope, attaching it to our telescope, along with the ASI120MM Mini camera. There are four USB2.0 ports on the rear of the ASIair and the cameras were immediately recognised, with all their key characteristics available to the control app. The guide camera has a USB-C (24-pin) connection, along with an ST4 connection if required. We were impressed with the sheer simplicity of setting it all up; astrophotography is so much more rewarding when the technology just works.

Opening up the autoguiding interface revealed a familiar setting, as PHD2 scope-guiding software is incorporated into the app. After finding a suitable guide star we started the calibration process. A short while later, as autoguiding began to work, our attention turned to the imaging process itself. Controlling the imaging camera is straightforward; just choose whether Light, Dark, Bias or Flat frames are required. Next, set the exposure time and number of pictures to take and hit the go button. This is hassle-free astroimaging with no laptop required. The pictures taken are saved on to a 32GB SD card, and can be transferred to a computer for processing, either by removing the SD card from the ASIair and using the supplied USB adaptor, or via Wi-Fi or Ethernet. The operating system for the ASIair is installed on the SD card. Basic instructions are provided but remember to take care when first using the equipment and to make a backup of the software.

Once everything was set up and running, the guiding was moving along happily and the images were being taken and saved, with a progress report displayed live on our phone. We even wandered away from the equipment, out of range of the Wi-Fi signal. When we returned the connection automatically refreshed itself and brought the app on our phone up to speed with what the camera had been doing while we were away, again, the process was seamless.

If you already have the appropriate ZWO cameras then the ASIair and auto-guiding bundle really simplifies astrophotography, making it easy to control everything using the phone in your pocket.

▲ **An image of the Orion Nebula, M42, as captured by a Sky-Watcher Esprit 150ED PRO refractor and an ASI294MC camera, controlled by the ASIair**

TIM JARDINE X 3

VERDICT

Assembly	★★★★½
Connectivity	★★★★★
Ease of use	★★★★½
Features	★★★★½
Guiding Accuracy	★★★★
OVERALL	★★★★½

KIT TO ADD

1. 12V 5A mains power unit

2. ZWO ASI294MC PRO USB3.0 Deep Sky Camera

3. TS-Optics 71SDQ APO refractor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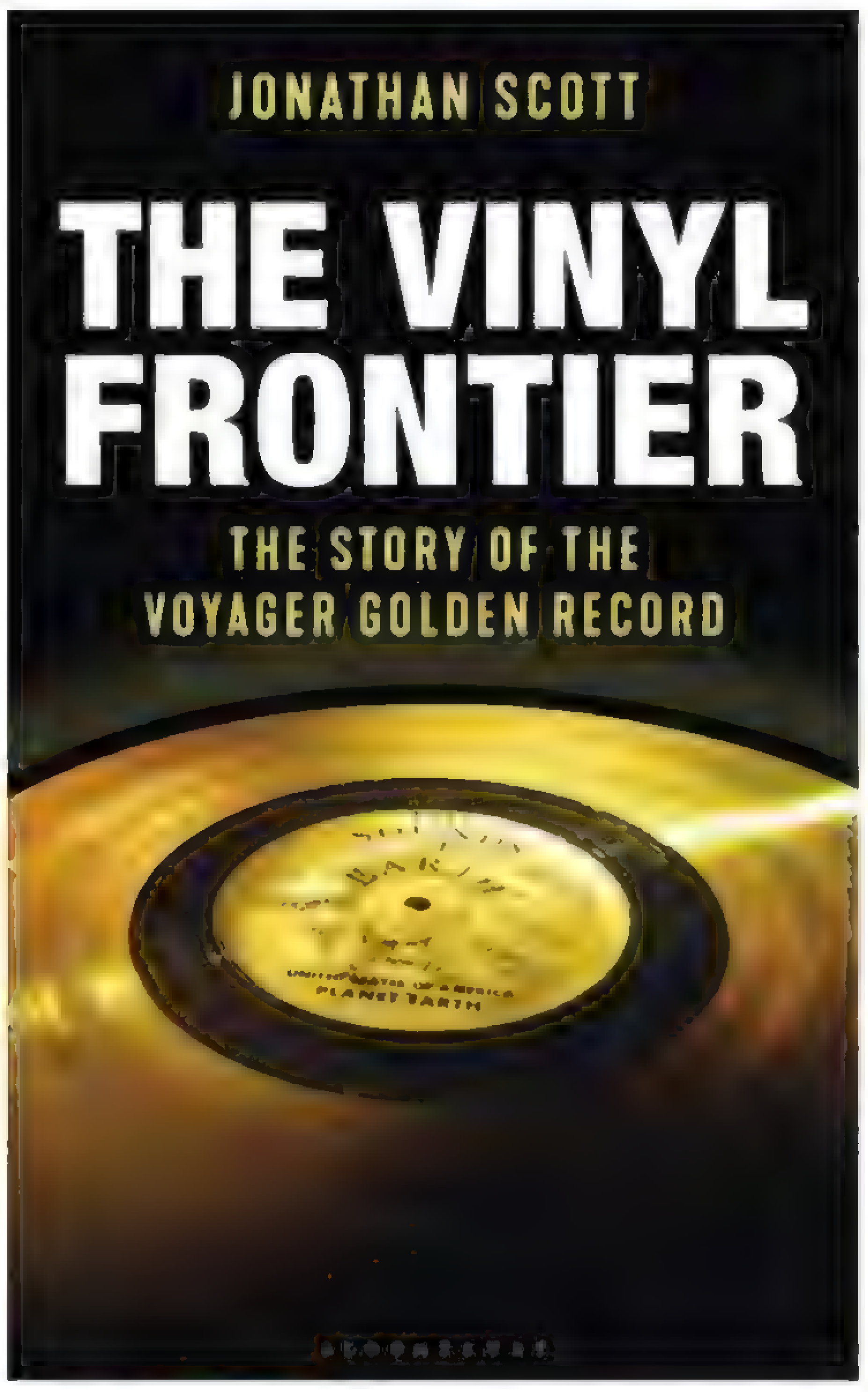


The Vinyl Frontier

Jonathan Scott
Bloomsbury
£16.99 ● HB

Lots of music books in recent years have told behind-the-scenes tales of how individual classic albums came to be. Here's another; except this album was crafted not for the music charts, but to document life on Earth for aliens who might discover it in some dim and distant future. In the summer of 1977 astronomer Carl Sagan led a small group of scientists and artists to create a copper and gold-plated record to be bolted onto the twin Voyager spacecraft before their journey to the outer Solar System. They had just six weeks to assemble a mixtape from humankind and make it flight ready, and as music journalist Jonathan Scott entertainingly recounts, they very nearly didn't make it.

The Voyager Golden Record contained sound and pictures (encoded into audio, 1990s internet dial-up style), including greetings in 55 languages (and whale song) plus sounds from everyday life – including a kiss – as well as 26 pieces of music from around the globe, which the book takes us through track by track.

This is not a standard space book, more resembling something like Nick Hornby's *High Fidelity*, with frequent asides, digressive footnotes and a comparison between Beethoven and the Stone Roses. Like *High Fidelity*, there's also a romance, as the author recounts how Sagan got together with the love of his life, writer Ann Druyan, as they worked on the project.

The book recalls Tim Ferris, the record's producer (and awkwardly Ann Druyan's then-fiancé), talking to Sagan and the latter saying "We got away with it" once the spacecraft were flying, adding to the sense that it was a lucky fluke somehow miraculously avoiding death by committee. Scott portrays the Golden Record as hailing from a specific time and sensibility, when sitting listening to an album without doing anything else at the same time was a normal thing to do. As he points out, it is a time capsule of post-1960s expansiveness and optimism, long since evaporated. Scott also notes that when the New Horizons spacecraft launched for Pluto and the Kuiper Belt in 2006 it carried no equivalent of the Golden Record; nobody even raised the idea. We should ask ourselves why that is.

▲ Scientists mounting the Golden record onto one of the Voyager probes

NASA/JPL-CALTECH

★★★★☆

***Sean Blair** writes for the European Space Agency website*

Interview with the author Jonathan Scott

How different do you think the Golden Record would be, if it were made today?

It might be strangled by committee or commercialism. Carl Sagan acted as a bulkhead between the creative team and NASA, which minimised meddling. That's not to say a version today would be bad, just that the 1977 environment allowed some idiosyncrasies, ordinary Joes and oddities to make it onto the record.

What are the main issues with creating a cosmic mixtape?

It's like choosing a tattoo that will still seem like a good idea in a billion years. In 1977 there was too little time to procrastinate. They had to ignore the magnitude of what they were attempting and make decisions.

What would you hope an alien civilisation might get from the record?

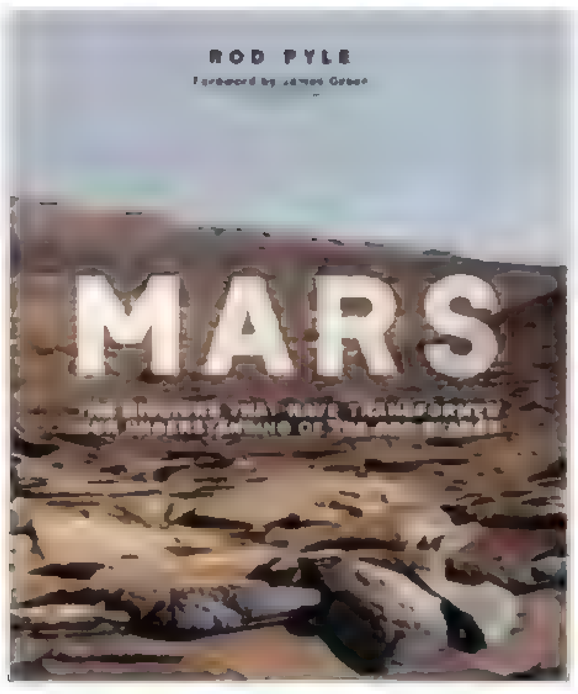
I hope they'd appreciate the effort. It might take them a while to crack the code of those cover hieroglyphs. Assuming they can see and hear, and that they manage to build a turntable and set the record revolving at the correct speed, and drop a needle in the right place, I suspect the rasping, beeping white noise of the picture sequence might leave them bemused at first. I imagine one saying: 'Well this one is little too avant-garde for me. Put 'Johnny B. Goode' on again!'

What would you add to the record?

I'd add 'Misalliance' by Flanders & Swann. It's a tale of forbidden love between two climbing plants, a hymn to freedom of choice and the destructive power of division.

***Jonathan Scott** is a music writer, astronomy enthusiast and former contributing editor to* Record Collector Magazine

Mars: The Missions That Have Transformed Our Understanding of the Red Planet



Rod Pyle
Andre Deutsch
£20 ● PB

Since antiquity, humans have been curious about Mars, although mankind's biggest steps towards really seeing the Red Planet were made in the 20th century. From the first flybys to the orbiters and current rovers on Mars, they have all revealed our neighbouring planet in mind-blowing detail and have their own bright history to share.

Author and NASA consultant Rod Pyle has written a lot about the history of space exploration, but his latest book is a masterpiece. Just as the legendary Mars Opportunity rover's mission has ended, this book captures the stories of the beginning of the mission and its fruitful working days on Mars. It also gives insight into other Mars missions from behind the scenes. Pyle writes about the mission scientists and the emotions felt as they witnessed the first ever landing on the Red Planet. He reveals the doubts and challenges the mission teams were facing while most of us on Earth were unaware of what was happening far beyond our own planet.

This book illustrates the brightest moments from different Mars missions and also talks about failures and lost spacecraft, spelling out the history of our species' curiosity with Mars and explorations of its surface. Mistakes transformed into victories, challenges turned into inventions and beautiful landscapes were explored as part of incredible scientific discoveries: these are the key moments of Martian exploration documented in Pyle's book. This is an excellent read, both for those who know a lot about Mars and those who have only recently become fascinated by the Red Planet. ★★★★★

***Sandra Kropa** is a science journalist and writer*

Gravity's Century: From Einstein's Eclipse to Images of Black Holes

Ron Cowen
Harvard University Press
£19.95 ● HB

The title of Cowen's first book nicely captures exactly what it's all about: the past century of research in gravitational physics. Mixed in with the science are anecdotes about some of the physicists who conducted the research, which really does help to bring the story to life.

We start of course with Einstein and how his General Theory of Relativity was developed. Cowen describes how Einstein became the first "science superstar" when Eddington and his team observed the bending of starlight during a solar eclipse, in accordance with his theory. The book goes on to discuss the ways in which we are trying to gain a better understanding of gravity and what it means. Cowen touches on the expansion of the Universe, imaging the black hole at our Galaxy's centre and, in my favourite chapter, quantum gravity.

The writer has a talent for explaining what can often be tough concepts and the maths behind them. Most of the time I felt I was just reading a story and the maths crept up on me. The 'deeper dive' sections are helpful additions, exploring in detail some of the ideas that would have been lost in a chapter. My only criticism is that Cowen missed an opportunity to showcase the increasing diversity of those in research when picking which stories to highlight.

Gravity's Century is remarkably easy to follow and read. If you are a keen beginner, or just interested in some of the people behind the science, read this book. ★★★★

***Dr Laura Nuttall** is a senior lecturer in gravitational waves at the University of Portsmouth*

Space Shuttle: A Photographic Journey

Luke Wesley Price
Ammonite Press
£30 ● HB

BOOK OF THE MONTH

It is hard to believe that nearly eight years have passed since the final orbital flight by one of NASA's fleet of Space Shuttles. Atlantis's mission in July 2011, 30 years after Columbia first orbited Earth, marked the end of a remarkable era in space exploration. That era is recorded in *Space Shuttle: A Photographic Journey* in images.

The Shuttle was the first reusable spacecraft. Its fleet of five flew 135 times into orbit. The many successful missions were, of course, marred by two tragic accidents that cost the lives of 14 astronauts in 1986 and 2003. Those dreadful events are recalled in the book, which begins with a dedication to the crews of Challenger and Columbia. However, the photos themselves, which appear throughout, focus on the positive aspects of the Shuttle project.

After a brief introductory text, the bulk of the book's pages are packed with colour images of each of the Shuttles showing them at every stage of their missions, from launch preparations through lift-off and orbit, to landing. Some of these photos will already be familiar as classics, but a lot of them will surely be new to readers. The author, a graphic designer by trade, worked with NASA to scour many thousands of photographs of the various Shuttles, and has presented them from a range of different perspectives. They are a delight to behold.

The book ends with a gallery of all the individual mission insignia, or 'patches', followed by pages listing key data for each flight – making this book also useful as a reference work. Most of all, however, it is the splendid collection of Shuttle images that makes this book so special. ★★★★★

***Paul Sutherland** is a space writer and journalist, author of* Philip's Essential Guide to Space

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 Apollo 10 flown foil and moon rock in acrylic

Price £239.99 • **Supplier** Space Collective
Tel 01342 837098 • **http://thespacecollective.com**

Keep a piece of Apollo history on your mantelpiece. This block contains a fragment of the Apollo 10 command module alongside a piece of lunar meteorite, along with a card with details of the mission.

2 Astroart 7

Price $165 (£125) • **Supplier** MSB Software
Tel +39 0544 527265 • **www.msb-astroart.com**

A complete suite of everything you need for astrophotography, from camera and telescope control through to image processing. This new version has been updated to give an easier, smoother user experience.

3 One giant leap socks

Price £10 • **Supplier** Royal Observatory Greenwich
Tel 0208 312 6700 • **https://shop.rmg.co.uk**

Make every step a giant leap with these socks. Each depicts an astronaut walking on the Moon with a Space Shuttle zipping past behind him. Fits men's shoe sizes 7 to 13.

4 EQ6Rail

Price £129 • **Supplier** Modern Astronomy
Tel 020 8763 9953 • **www.modernastronomy.com**

This rail helps to remedy a common flaw with the popular EQ6 mount, where the adjustment bolt hits the mount and bends. This rail provides a curved surface, allowing smooth use of the mount between latitudes of 15–75°.

5 Bresser Barlow lens 5x (1.25-inch)

Price €49 (£42) • **Supplier** Bresser
Tel +49 2872 80740 • **www.bresser.de**

Whether you're doing astrophotography or visual astronomy, this Barlow lens will let you extend the effective focal length of your telescope, increasing the magnification by a factor of five.

6 Orion StarShoot P1 polar alignment camera

Price £284.99 • **Supplier** Orion
Tel 0800 041 8146 • **http://uk.telescope.com**

Polar align your equatorial telescope in a matter of minutes using this system. The camera attaches to your telescope, then the accompanying software offers step by step instructions to align your mount. The Orion P1 will require computer support.

Shaoni Bhattacharya interviews leading experts in space science

Q&A WITH PATRICK MICHEL

Grains collected from the surface of the Near-Earth Object Ryugu by JAXA's Hayabusa 2 mission could give clues to how life emerged on Earth

▲ An artist's impression of Hayabusa 2, which is taking geological samples from the asteroid Ryugu

JAXA

How does Hayabusa 2 build on the previous mission? Hayabusa 2 launched on 3 December 2014 and arrived at the asteroid Ryugu on 27 June 2018. The first Hayabusa mission, launched in 2003 by JAXA (the Japanese Aerospace Exploration Agency) to the asteroid Itokawa, was a technological demonstration. Itokawa was chosen because it was the 'cheapest' to get to. This time the target was chosen to match the science objectives that we had – to understand the composition of the building blocks of the planets, and also to understand the role of asteroids in the emergence of life on Earth.

What could asteroid soil tell us about the origins of the Solar System? It can tell us about this asteroid – its age, the shock levels it has experienced, and also about the big picture. It could tell us how the Solar System formed and how life on Earth may have come about.

Ryugu is a C-type asteroid, meaning it's a carbon-rich type. We believe these objects formed further from the Sun than silicate-type objects like Itokawa, therefore they may have experienced less heating and be more representative of the original material of the Solar System that made the planets. These objects are small so they never experience a lot of heating – unlike planets. Therefore, they can allow us to trace back the original material that made the planets.

Because Ryugu is a carbon-rich asteroid, we believe that it may be rich in organic material, and have water in the form of hydrated minerals. We built scenarios telling us that at the end of the Earth's formation there were a lot of impacts; one idea is that asteroids brought water and organic materials that made life possible.

Why do we think the asteroids might have organics? We've found carbon-rich meteorites – which were originally asteroids – on Earth, which contain amino acids. We also measure the properties of water, in particular the deuterium to hydrogen (D/H) ratio that matches that of Earth's oceans. But these meteorites suffer contamination, and they are also biased towards the strongest materials that can survive Earth's atmosphere. By taking a sample from an asteroid itself and returning it to Earth, you remove this bias. You also get the geological context of the samples required to understand their analysis.

Dr Patrick Michel is director of research at CNRS, Côte d'Azur Observatory in Nice, France, and a science team member on JAXA's Hayabusa 2 mission

How did you collect the sample of asteroid soil? There is a sample horn about 70cm in length, which is like a mosquito's nose. When it touches the surface it fires a small projectile of 5g which impacts at 300m/s.

Then the spacecraft goes up again – it's a 'touch and go' approach. The impact creates ejecta and you can capture fragments as big as 1cm. The target is to collect 100mg of samples. We won't know how much and whether we have any samples until the capsule is returned to Earth. We are looking very carefully at all the images to confirm if it's likely that we've got samples.

What other key events are planned for the mission? In early April we will conduct a hypervelocity impact experiment. We will deploy a little box which will stay at a distance from the surface while the spacecraft goes behind the asteroid. When the spacecraft is in a safe position the box will explode and release a 2kg copper projectile that will impact the surface at 2km/s to make a crater. This allows us to test our predictions about crater size being dependent on impact energy.

This is important because we estimate the age of a surface by counting the number and size of craters. For that, we need to work out the relation between the projectile size and the size of the crater. Normally big craters need bigger projectiles, but suppose we find that with a small impact you generate a big crater?

The second aim will be to bring back the spacecraft and possibly take a sample of the subsurface from the crater. I would expect this to be sometime from mid-May to June.

The spacecraft will leave the asteroid this December, and will be back to Earth in December 2020. But before that happens, the adventure continues. My Japanese colleagues are amazing and the suspense is still at its highest level.

THE SOUTHERN HEMISPHERE

With Glenn Dawes

May's eastern sky offers a chance to see a close encounter of Mercury and Venus

When to use this chart

1 May at 00:00 AEDT (13.00 UT)
15 May at 23:00 AEDT (12.00 UT)
31 May at 22:00 AEDT (11.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

MAY HIGHLIGHTS

The eastern dawn sky on 3 May presents a spectacular conjunction, the thin crescent (27-day old) Moon is 4° to the lower right of brilliant Venus. Mercury is also obvious being 5° directly below the Moon. The best time to observe this event is one hour before sunrise (at 05:30 AEDT). Venus is dropping towards its next solar conjunction as Uranus rises out of the Sun's glow. These planets pass each other, being closest on 19 May at only 1°, and visible in binoculars.

STARS AND CONSTELLATIONS

Low in the northern evening sky lies the prominent star Arcturus. It is the alpha star to the constellation of Boötes, forming the top luminary of its inverted kite pattern. Arcturus also holds a place in history, with its light generating an electric charge used to open the 1933 Chicago World's Fair. But why this specific star? At the time Arcturus was thought to be 40 lightyears away and that the light used in 1933 would have left the star at the time Chicago held its previous World Fair in 1893.

THE PLANETS

Mars continues its presence low in the northwestern twilight sky during May. As Jupiter approaches opposition next month, it arrives around the time the Red Planet departs, being visible for most of the night. Saturn soon follows its fellow gas giant into the eastern sky, with both transiting in the morning hours. Turning to the morning, Venus rises just before dawn all month. May commences with Mercury just below Venus but this inner world is lost to the solar glare by mid month.

DEEP-SKY OBJECTS

We take a deep-sky dive into Coma Berenices. Starting at the naked-eye (mag. +4.3) star Alpha Com, move 5° northwest to find triple star 35 Comae Berenices (RA 12h 53.3m, dec. +21° 15'). Two yellow and blue components, at mag. +5.1 and +9.1, are visible separated by 28 arcseconds. Increasing a scope's power reveals the primary to have a mag. +7.2 companion (also yellow) 1.2 arcseconds away.

Almost sharing the same field with 35 Com (0.9° NE) is one of Coma's gems, the 'Black Eye Galaxy' NGC 4826 or M64 (RA 12h 56.7m, dec. +21° 41'). This mag. +8.4 spiral has a bright, mottled surface. Large 15cm telescopes reveal its core has a dark region in the northeast quadrant, giving rise to its nickname. Larger apertures shows it as a narrow black band just inside the core's edge.

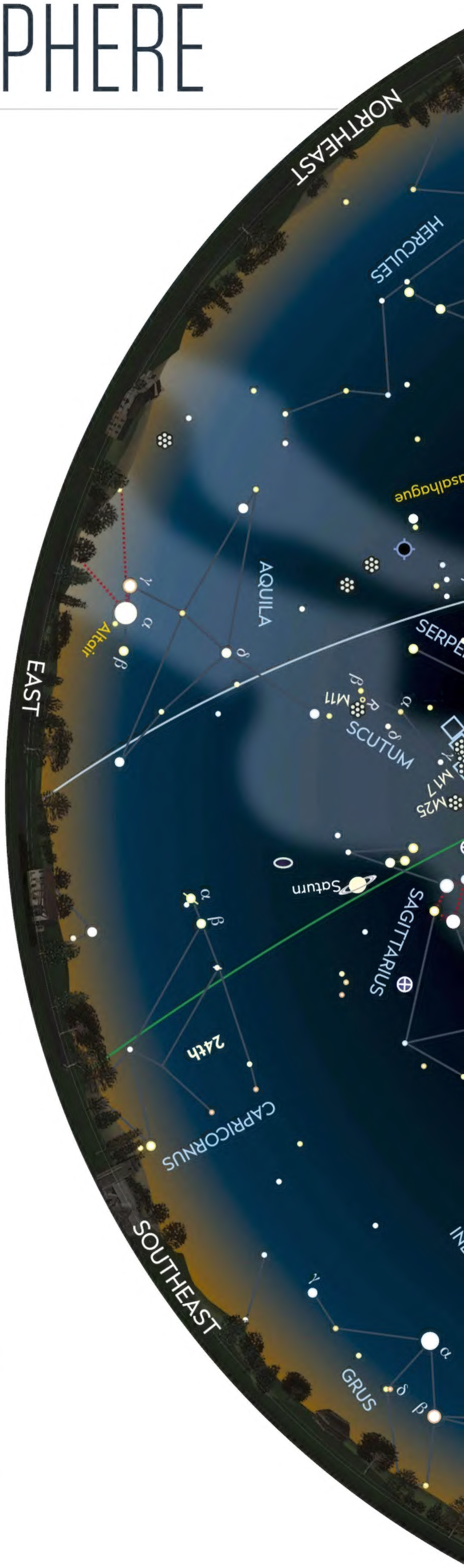


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
M92
M13
Keystone
BOÖTES
M51
M106
CANES VENATICI
M63
M94
Cor Caroli
URSA MAJOR
COMA BERENICES
NGC 4565
M3
CORONA BOREALIS
Kite
Arcturus
Rasalgethi
M53
35
M64
Diadem
LEO
Sickle
OPHIUCHUS
SERPENS CAPUT
M60
M87
M86
VIRGO
M66
Leo Triplet
12th
15th
M5
Celestial Equator
Regulus
M12
M10
18th
Ecliptic
Spica
M104
LIBRA
CORVUS
CRATER
HYDRA
Alphard
M16
21st
M23
M20
Jupiter
Antares
M80
M4
M83
CENTAURUS
Ghost of Jupiter
M8
M6
SCORPIUS
LUPUS
M7
Teapot
NORMA
ω Cen
ANTLIA
CRUX
CORONA AUSTRALIS
TELESCOPIUM
ARA
CIRCINUS
Jewel Box
Coal Sack
NGC 3699
VELA
PYXIS
PUPPIS
TRIANGULUM AUSTRALE
MUSCA
Peacock Star
APUS
CHAMAELEON
PAVO
OCTANS
South Celestial Pole
CARINA
False Cross
VOLANS
SMC
HYDRUS
47 Tuc
Tarantula Neb
MENSA
LMC
PICTOR
Canopus
TUCANA
DORADO
RETICULUM
Achernar